Government of Canada | Gouvernement du Canada
Canadian Forestry Service | Service canadien des forêts

The status of the Spruce Budworm in Newfoundland and Labrador in 1982

A.G. Raske, L.J. Clarke, W.J. Sutton

Information Report N-X-234
Newfoundland Forestry Centre

87-03040/

NEWFOUNDLAND FORESTRY CENTRE

The Newfoundland Forestry Centre (NeFC) is an establishment of the Canadian Forestry Service. The Centre conducts most of the forestry research in the Newfoundland Region and is one of six similar regional establishments in Canada.

The objective of NeFC is to provide the scientific, technological and economic information and services required for the improvement, protection, and efficient utilization of the forest resources of the province of Newfoundland and Labrador. Its work is directed towards satisfying the requirements of the Provincial Government, the forest industry, federal agencies having forestry related programs and other clients of the Canadian Forestry Service; many of its studies are undertaken jointly with client agencies. The Centre attempts to bring the results of research to potential users by publishing information reports, articles in scientific journals, and by demonstrations of research results. It seeks to keep the public informed of its work by means of special displays, seminars, and related activities.

The NeFC program has three principal components - Forest Resources and Environmental Research, Forest Protection Research, and Forestry Development.

THE STATUS OF THE SPRUCE BUDWORM IN NEWFOUNDLAND AND LABRADOR IN 1982

by A.G. Raske, L.J. Clarke and W.J. Sutton

INFORMATION REPORT N-X-234
1986

CANADIAN FORESTRY SERVICE
NEWFOUNDLAND FORESTRY CENTRE

©Minister of Supply and Services Canada 1986

ISSN NO. 0704-7657
CAT. NO. Fo46-15/234E
ISBN NO. 0-662-15319-7

Copies of this report are available at no charge from:

Newfoundland Forestry Centre
Canadian Forestry Service
P.O. Box 6028
St. John's, Newfoundland
Canada A1C 5X8

Telephone No. 709-772-4117

ABSTRACT

The productive softwood forests of Newfoundland and Labrador were resurveyed in 1982 to assess population levels of the spruce budworm (Choristoneura fumiferana (Clem.)), and the effect of natural control factors on populations, to delineate and stratify subsequent defoliation, and to estimate the cumulative area and volume of stands in various damage classes. Tree mortality occurred on 469 000 ha of merchantable softwood stands containing a total timber volume of 48 674 000 m^3. These stands contained an estimated 21 076 000 m^3 of dead trees and 1 584 000 m^3 of moribund trees. Moderate and severe defoliation occurred on 41 100 ha of softwood stands in 1982. The total area of immature stands containing dead trees was 64 800 ha.

Spring and early summer weather in 1982 was cooler than average and larval feeding lagged behind shoot development by two to three weeks. Larval populations collapsed from July 5 to July 12 in many outbreak areas between the sixth-instar larval and the pupal stages. Parasitism was about 10% and 15% were diseased.

Moderate and severe defoliation is forecast on 109 300 ha in 1983 in productive forests.

RÉSUMÉ

En 1982, on a effectué un nouveau relevé des forêts productives de résineux à Terre-Neuve et au Labrador pour évaluer les populations de la tordeuse des bourgeons de l'épinette (Choristoneura fumiferana (Clem.)) ainsi que l'effet des facteurs limitants naturels de ces populations, pour délimiter et stratifier la défolition qui s'ensuit et pour estimer la superficie et le volume cumulatifs de bois des peuplements endommagés à divers degrés. Dans des peuplements de résineux contenant au total 48 674 000 m^3 de bois merchand et s'étendant sur une superficie de 469 000 ha, on a estimé qu'il y avait pour 21 076 000 m^3 d'arbres morts et 1 584 000 m^3 d'arbres moirbonds. En 1982, 41 100 ha de résineux ont subi une défoliation de modérée à grave. La superficie totale des peuplements immatures contenant des arbres morts était de 64 800 ha.

Au printemps et à l'été de 1982, les conditions atmosphériques approachaient de la moyenne. Au printemps, les populations de larves ont été assez fortes pour causer une grave défoliation, mais elles ont énormément diminué à la fin de juin et au début de juillet dans la plupart des aires d'infestation et seulement la moitié de la superficie prévue a été gravement défoliée. Les parasites ont causé 10% de a mortalité, les maladies, 15%.

On prévoit qu'en 1983 il y aura une défoliation de modérée à grave sur 109 300 ha de forêts productives.

TABLE OF CONTENTS

	Page
ABSTRACT	i
RÉSUMÉ	i
LIST OF TABLES	iii
LIST OF FIGURES	v
LIST OF APPENDICES	vi
ACKNOWLEDGEMENTS	vii
I. INTRODUCTION	1
II. THE SPRUCE BUDWORM OUTBREAK IN 1982	1
a) Host Condition at the Beginning of 1982	1
b) Forecast of Budworm Infestation for 1982	2
c) Larval Development	2
d) Natural Control Factors	6
e) Moth Flight	9
f) Defoliation Estimates	9
g) Damage Assessment	10
III. THE SPRUCE BUDWORM SPRAY PROGRAM IN 1982	23
a) Spray Operations	23
b) Environmental Monitoring	23
IV. FORECAST OF BUDWORM INFESTATIONS FOR 1983	25
V. SUMMARY AND CONCLUSIONS	32
VI. LITERATURE CITED	34
VII. APPENDICES	36

LIST OF TABLES

		Page
1.	Weekly mean density of spruce budworm, Choristoneura fumiferana (Clem.) in Newfoundland in 1982	5
2.	Number of spruce budworm larvae, pupae and empty feeding tunnels at four locations in Newfoundland in 1982	7
3a.	Result of FIDS spruce budworm rearings in 1982 in Newfoundland.	8
3b.	Results of spruce budworm rearings from research plots in 1982 in Newfoundland	8
4.	Area (ha) of defoliation caused by the spruce budworm in productive forests of Newfoundland and Labrador in 1982	9
5.	Total cumulative area and volume of productive merchantable stands where tree mortality caused by the spruce budworm was evident in Newfoundland in 1982	11
6.	Areas and volume of budworm damaged stands in Newfoundland salvaged by 1982	14
7.	Areas and volume of budworm damaged stands in Newfoundland destroyed by wildfire by 1982	14
8.	Areas and volume of budworm damaged stands in Newfoundland classed as NSR in 1982.....	15
9.	Areas and volumes of budworm damaged stands in Newfoundland that have blown down and were not salvable by 1982	16
10.	Existing areas and volume of productive merchantable stands where tree mortality caused by spruce budworm was evident in Newfoundland in 1982	16
11.	Standing areas and volume of budworm damaged merchantable stands in Newfoundland that are unsalvable because they have been dead five years or more	17
12.	Salvable areas and volumes of productive merchantable stands where tree mortality by the spruce budworm was evident in Newfoundland in 1982	18
13.	Areas in ha of productive sub-merchantable stands where tree mortality was evident in Newfoundland in 1982	22

Page

14. Areas of light, moderate and severe defoliation and moderate and high hazard forecast in productive forests of Newfoundland and Labrador in 1983 27

15. Average number of spruce budworm egg-masses per 10 m^2 from 1977 to 1982 in three regions in Newfoundland and Labrador 30

16. Summary of spruce budworm egg-mass numbers per 10 m^2 of foliage foliage for sample points with moderate and severe defoliation forecast in Newfoundland from 1978 to 1982 31

LIST OF FIGURES

		Page
1.	Areas of light, moderate and severe spruce budworm defoliation forecast for 1982 in Newfoundland and Labrador	3
2.	Areas of moderate and high spruce budworm damage hazard forecast for 1982 in Newfoundland and Labrador	4
3.	Areas of light, moderate and severe spruce budworm defoliation in Newfoundland in 1981	12
4.	Areas of light, moderate and severe spruce budworm defoliation in Newfoundland in 1982	13
5.	Areas of dead, moribund and very severely damaged stands in Newfoundland in 1981	19
6.	Areas of dead, moribund and very severely damaged stands in Newfoundland in 1982	20
7.	Areas sprayed with Matacil and B.t. in Newfoundland in 1982 ..	24
8.	Areas of light, moderate and severe defoliation by the spruce budworm forecast in Newfoundland for 1983	28
9.	Areas of moderate and high hazard from spruce budworm defoliation forecast in Newfoundland for 1983	29

LIST OF APPENDICES

		Page
I.	Productive forest areas of Newfoundland and Labrador	37
II.	Major geographic regions of Newfoundland and Labrador; I = western, II = central, III = eastern, IV = Labrador ...	38
III.	Forest management units in Newfoundland and Labrador	39
IV.	Environmental monitoring of the 1981 spruce budworm spray program	40
V.	Average number of spruce budworm larvae per FIDS sample in three regions of Newfoundland and Labrador from 1977 to 1982	41
VI.	Number of egg-mass sample locations by predicted defoliation classes and geographical regions from 1977 to 1982 in Newfoundland and Labrador	42
VII.	Numerical values of tree conditions and hazard rating system used to forecast losses in spruce budworm infested stands	43
VIII.	Total cumulative area and volume of productive merchantable stands by ownership and management unit where tree mortality caused by the spruce budworm was evident in Newfoundland in 1982	44
IX.	Areas and volume of productive merchantable stands salvaged by 1982 by ownership and management unit where tree mortality caused by the spruce budworm was evident in Newfoundland	46
X.	Area and volume of productive merchantable stands burned by wildfire by 1982 by ownership and management unit, where tree mortality caused by the spruce budworm was evident in Newfoundland	47
XI.	Areas and volume of budworm damaged stands in Newfoundland classed as NSR in 1982	48
XII.	Areas and volume of stands in Newfoundland that have blown down and were not salvable by 1982	49
XIII.	Existing areas and volumes of productive merchantable stands by ownership and management unit where tree mortality by the spruce budworm was evident in Newfoundland in 1982	50

ACKNOWLEDGEMENTS

We gratefully acknowledge the cooperation of the Newfondland and Labrador Department of Forest Resources and Lands in providing the Forest Insect and Disease Survey, Canadian Forestry Service with aircraft, part-time assistance and forest inventory figures. We thank forestry personnel in industry who provided data from their permanent sample plots.

We thank the FIDS field and laboratory technicians: E.C. Banfield, D.S. O'Brien, D.M. Stone, and K.E. Pardy who made a major contribution to this report through their observations, aerial mapping rearing budworm samples and procurement of data. We thank E.J. Dobesberger for the use of his budworm population data and K.P. Lim for the use of larval-mortality data. Special thanks are due to D.M. Stone who prepared the figures used in this report. The typing of this report by Mrs. H. Dunphy and the final copy by M.F. Gillingham is gratefully acknowledged.

THE STATUS OF THE SPRUCE BUDWORM IN NEWFOUNDLAND AND LABRADOR IN 82

by

A.G. Raske, L.J. Clarke and W.J. Sutton

I. INTRODUCTION

The eastern spruce budworm, (Choristoneura fumiferana (Clem.)) continued to be the most important forest pest in the province of Newfoundland in 1982, although population levels and the size of the outbreak decreased. The most recent outbreak of this insect in eastern North America in the 1970s has caused severe damage to balsam fir (Abies balsamea (L.) Mill.) throughout eastern Canada. The outbreak abated somewhat in Canada in the early 1980s, but still is active in large areas of forested land. In Newfoundland, balsam fir has been extensively damaged and black spruce (Picea mariana (Mill.) B.S.P.) has also sustained considerable mortality.

This report is the sixth in a series on the status of the spruce budworm in Newfoundland published by the Newfoundland Forestry Centre. The first summarized all known outbreaks, and documented the latest outbreak to 1977 (Otvos and Moody 1978), and the others have been annual updates of the current outbreak (Moody and Otvos 1979; Moody 1980; Raske and Clarke 1982 and Raske et al. 1982). Two reports described methods of assessing damage (Moody 1979, Sutton 1981). This report presents results of spruce budworm surveys in 1982, and forecasts infestation areas and hazard levels for 1983. Modifications in methods from those previously used are described in detail.

II. THE SPRUCE BUDWORM OUTBREAK IN 1982

a) Host Condition at the Beginning of 1982

The collapse of the spruce budworm infestation throughout most of the Island in 1981 curtailed any major increase in area where tree mortality was occurring in 1982. The only new location with tree mortality in 1981 was 1 300 ha in the Gander Bay area. However, the proportion of tree mortality within existing damaged areas increased. At the beginning of 1982 the total area of dead balsam fir stands (more than 50% of the total tree volume dead) was about 197 000 ha; up 28 000 ha from the previous year. The area of dying fir stands (20-49% of the total tree volume dead and more than 50% dying) was about 109 000 ha; a decrease of 78 000 ha, and the area of severely damaged stands (5-19% of total tree

volume dying) was about 38 000 ha; a decrease of 33 000 ha from the previous year. The total area containing stands with tree mortality was 344 000 ha. Of that about 35 000 ha of dead stands were removed from the inventory and classed as areas in need of restocking, because the dead trees on these areas would or could not be salvaged. Thus, only 309 000 ha of damaged stands remained on the provincial forest inventory; 344 000 ha were reported for the end of 1981 (Raske et al. 1982).

The lack of further defoliation in many areas in central and eastern Newfoundland in 1981 provided the first opportunity for recovery of fir in those areas. Areas in the western region continued to recover except in small areas where the infestation continued. On the average, living fir trees had a cumulative total of 43% of their total foliage removed and living black spruce 30%.

b) Forecast of Budworm Infestation for 1982

The forecast of severity of budworm infestation and its extent for 1982 was based on an egg-mass survey of 807 sample points across the island and 10 points in Labrador. About 99% of the branch samples were checked by a second person. The branches of about 200 of these sample points were also washed for overwintering larvae to supplement the results of the egg-mass survey, by refining boundaries of areas forecast to be infested.

The area of moderate and severe defoliation was forecast to be about 21 000 ha and an additional 134 000 ha were forecast to have light defoliation for a total of 155 000 ha (Fig. 1). This was a considerable reduction from the 380 000 ha of moderate and severe defoliation recorded in 1981. The areas of high-hazard were forecast to be 71 000 ha in 1982 (Fig. 2); considerably reduced from the 780 000 ha of high-hazard forests predicted for 1981.

c) Larval Development

In 1982 cool and wet weather was more common in late May and early June than average and beginning of larval feeding was generally delayed about two to three weeks compared to the long-term average and also compared to 1981. However, shoot growth of balsam fir occurred near the average time and about two weeks ahead of larval development. This was the second year in succession that host development was ahead of larval development. Late June and early July weather was near average and without extremes, and late-larval development appeared normal.

Results of larval sampling demonstrated a rapid drop in population levels between the sixth instar larval and pupal stage (Table 1). Population levels were less than five larvae per branch at all locations,

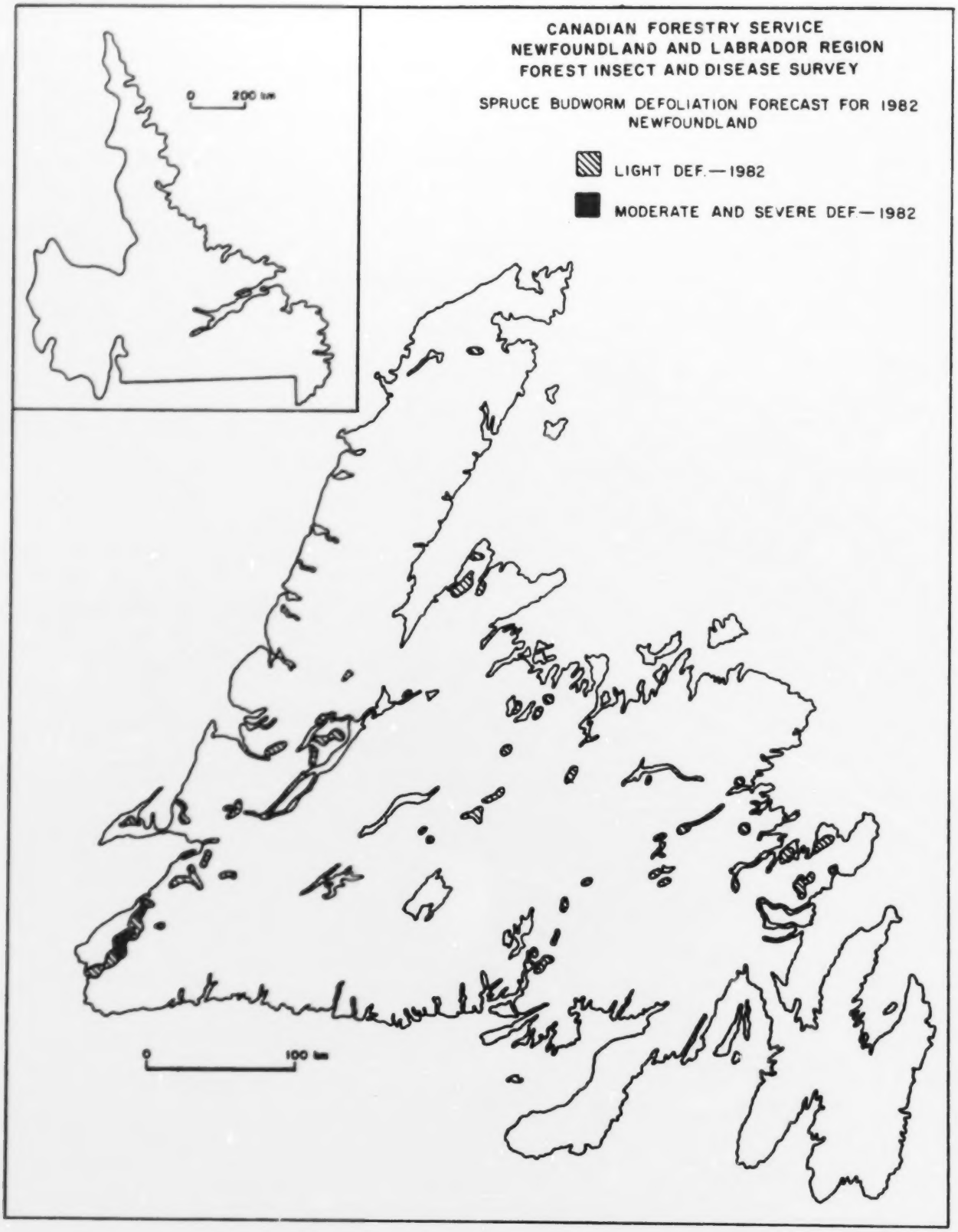


Figure 1. Areas of light, moderate and severe spruce budworm defoliation forecast for 1982 in Newfoundland and Labrador.

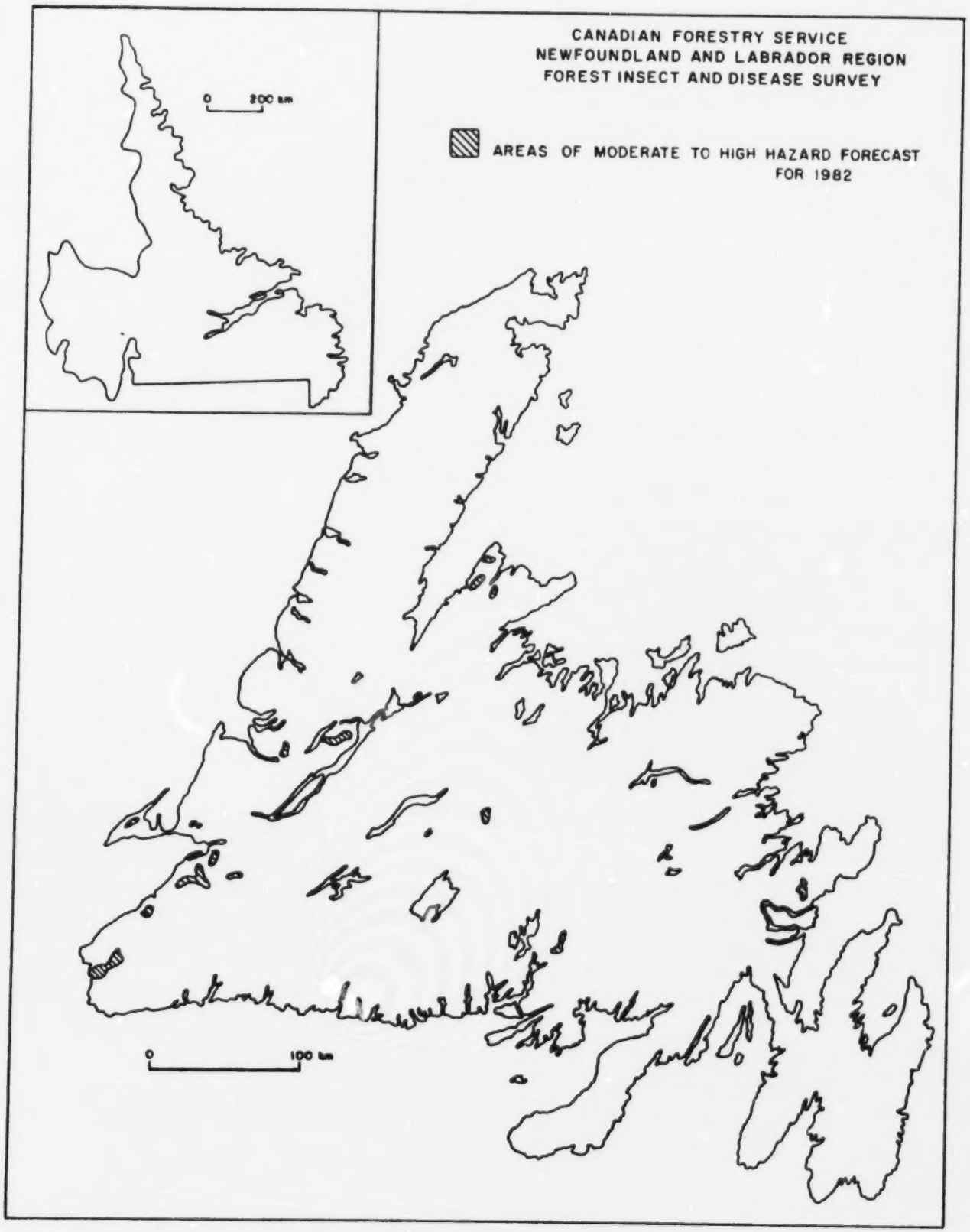

CANADIAN FORESTRY SERVICE
NEWFOUNDLAND AND LABRADOR REGION
FOREST INSECT AND DISEASE SURVEY
AREAS OF MODERATE TO HIGH HAZARD FORECAST FOR 1982
0 200 km
0 100 km

Figure 2. Areas of moderate and high spruce budworm damage hazard forecast for 1982 in Newfoundland and Labrador.

Table 1. Weekly mean density of spruce budworm, Choristoneura fumiferana (Clem.), in Newfoundland, 1982.

Week beginning	Stadium	Mean Density/45 cm Branch Tip[1]						
		Robinsons	Gallants	Pasadena	Baie Verte	Gullbridge Mine Road	Lake Ambrose	Jamestown
7 June	L_2-L_4	2.80	1.12	1.95	0.58	0.05	0.08	0.15
14 June	L_2-L_4	-	-	1.00	-	-	-	-
21 June	L_4-L_5	4.42	2.20	2.03	0.13	0.35	0.50	0.05
28 June	L_5-L_6	4.25	2.53	2.73	0.28	0.10	0.13	0.35
5 July	L_5-L_6	3.83	1.63	2.90	0.55	0.03	0.08	0.52
12 July	L_6/Pupal	1.53/0.10	1.23/ -	2.13/ -	0.13/ -	0.05/ -	0.13/ -	0.13/ -
19 July	L_6/Pupal	0.53/0.78	0.15/0.18	2.23/0.13	0.25/0.03	-	-	0.15
26 July	L_6/Pupal	0.05/0.45	- /0.03	0.35/1.15	0.03/ -	0.03/ -	-	0.05/0.08
	Adult	0.13	-	0.05	-	-	-	-
2 Aug.	Pupal	-	0.03	0.65	0.03	0.03	-	0.05
	Adult/Egg Mass	0.08/ -	0.03/ -	0.23/0.03	- / -	- / -	- / -	- / -
9 Aug.	Pupal	-	-	0.05	0.03	-	-	-
	Adult/Egg Mass	0.35/ -	- / 0	0.53/0.90	- / -	- / -	- / -	- / -

[1]The sample unit is one, first-order, mid-crown branch from balsam fir, Abies balsamea (L.) Mill. The sample size is 40 (n = 40).

and above one larvae per branch only for the western areas. Population levels decreased rapidly between July 5 and July 12. The number of budworms per branch remained above two only at Pasadena.

An unusual behavior was noted in several areas where larvae occurred in early July, the sixth instar larvae appeared to do little feeding and many empty feeding tunnels were found by July (Table 2), including very little feeding in or very close to the tunnel. In other areas up to 95% empty feeding tunnels were recorded and up to 20 empty tunnels per live budworm. In all these areas the number of pupae was greatly reduced from those expected. Very few dead larvae and pupae were found on the branches compared to the number that should have been there; even allowing for a normal amount of mortality. This was also observed in other areas where no data were collected.

Larval sampling by Forest Insect and Disease Survey Rangers continued as in previous years (Appendix V). Average number of budworm larvae per tree beating sample decreased again in 1982. It averaged ten in 1982 as compared to 17 in 1981. However, in central and eastern Newfoundland the decrease was more pronounced, from an average of 16 to three in 1982. The average number of larvae per branch sample also decreased for 8.8 in 1981 to 2.8 in 1982.

d) Natural Control Factors

Spruce budworm larvae and pupae were sampled throughout the island in 1982 to determine rates of parasitism and the prevalence of diseases. Results from samples by Forest Insect and Disease Survey Rangers and samples collected for research purposes were similar (Table 3a, 3b). About 68% emerged as adults, 14% were diseased, 11% were parasitized, 6% died of unknown causes, and about 1% died during rearing (missing, injured, etc.).

Total parasitism of 11% was slightly higher than the 8% recorded for 1981. Apanteles fumiferanae (Vier.) and Glypta fumiferanae (Vier.) continued to be the dominant larval parasite species, and Phaeogenes hariolus (Cress.) and Ephialtes (= Apechthis) ontario (Cress.) the dominant pupal parasites (Dobesberger and Lim 1983).

Fungal infection, mainly by Zoophthora radicans (Bref.) was 12% in 1982, a considerable increase from 1% in 1981, but back to its long-term average of about 10%. The incidence of the microsporidian disease, Nosema fumiferanae (Thom.), decreased to 2% in 1982 from about 7% in 1981. Microsporidia tend to be only debilitating and alone rarely cause mortality.

Table 2. Number of spruce budworm larvae, pupae and empty feeding tunnels at four locations in Newfoundland in 1982.

Location	Percent Defoliation	No. branches sampled	Total Spruce Budworm Numbers				Empty feeding tunnel		No. empty tunnels per occupied tunnel
			Larvae in tunnels	Pupae in tunnels	Pupae out of tunnel	Empty pupal cases	No.	Percent	
Pasadena	40	30	55	344	77	0	687	59	1.7
Corner Brook	15	30	15	87	25	0	250	67	2.5
Gallants	5	30	12	57	24	0	325	78	4.7
Bellburns	0	10	1	1	0	0	15	88	7.5

Table 3a. Result of FIDS spruce budworm rearings in 1982 in Newfoundland.

FIDS district	Total no. reared	No. moths emerged	No. parasitized	No. missing	No. dead by misc.	No. diseased & dead by unknown causes*
Bonavista	65	54	5	0	1	5
Grand Falls	15	14	0	0	0	1
St. George's	645	421	64	5	2	153
Humber	328	254	22	3	1	48
Goose Bay	6	2	3	0	0	1
Total	1059	745	94	8	4	208
Percentage of total		70%	9%	1%	-	20%

*Those that died of diseases (14%) and of unknown causes (5%) known for the total only.

Table 3b. Results of spruce budworm rearings from research plots in 1982 in Newfoundland.

	LARVA				PUPA			
			Percent diseased				Percent diseased	
Location	Total reared	Percent parasitism	Nosema	Fungi	Total No. reared	Percent parasitism	Nosema	Fungi
Robinsons	472	22.5	4.7	13.6	53	7.5	-	-
Gallants	331	8.8	4.5	14.5	5	-	-	-
Pasadena	1129	6.8	0.9	10.4	121	0.6	0.2	-
Baie Verte	191	3.1	-	-	2	50	-	-
Gullbridge Mine Road	23	21.7	-	30.4	-	-	-	-
Lake Ambrose	33	15.2	-	27.3	-	-	-	-
Jamestown	48	16.7	-	22.9	5	20	-	-
	2227	10.6	2.1	11.5	186	7.0	1.1	-

e) Moth Flight

Numerous budworm moths were found between July 8 and 17. Pheromone trapping confirmed the presence of moths throughout western and central Newfoundland. At that time about 91% of the native Newfoundland budworm population was in the fifth and sixth larval instars, less than 1% had pupated, and no locally-emerged budworm could be found. More than 80% of sweep-net samples were males, suggesting that most of the moth-flight into Newfoundland were males and would not lay eggs. Dobesberger et al. (1983) felt that the moths probably emigrated with the aid of suitable weather from New Brunswick to Newfoundland.

f) Defoliation Estimates

The annual aerial defoliation survey began in late July 1982 in Labrador and was completed by mid-August for the rest of the Province. Defoliation classes used were the same as in recent years. The total areas of light, moderate and severe defoliation in the productive forests of the island was about 90 000 ha, of which 41 000 ha were in the moderate and severe categories (Table 4). These areas are a considerable reduction from the corresponding figures for defoliation for 1981 at 400 000 ha and 380 000 ha. However, the moderate and severe defoliation was double the 21 000 ha forecast for 1982, but the area of light defoliation was considerably less than the 134 000 ha forecast.

Table 4. Area (ha) of defoliation caused by the spruce budworm in productive forests of Newfoundland in 1982.

Management Unit No.	Defoliation Class[1]			
	Light	Moderate	Severe	Total
9	900	-	200	1 100
12	2 800	-	800	3 600
14	35 300	2 900	18 000	56 200
15	10 200	1 200	18 000	29 400
19 (Labrador)	-	-	700	700
Total Island	49 200	4 100	37 000	90 300
Total Labrador	-	-	700	700

[1]Light 1-25%
Moderate 26-75%
Severe 76-100%.

Comparing defoliation maps of 1981 and 1982 (Figs. 3 and 4) it is apparent that a major reduction occurred in central and eastern Newfoundland, and that areas of infestation in western Newfoundland also were greatly reduced. The moderate and severe defoliation was distributed in several areas from St. Andrews to Deer Lake, in a small area on the Baie Verte Peninsula, and a small area along Noel Paul's Brook. In Labrador two small infestations, of 330 ha each, continued in mature balsam fir and white spruce near Goose Point and along the Beaver River near Grand Lake.

g) **Damage Assessment**

The 1982 damage assessment was a cooperative effort between the Newfoundland Forestry Centre of the Canadian Forestry Service and the Newfoundland Department of Forest Resources and Lands. Methods of estimating areas and volumes of spruce budworm damaged timber from 1974-77, and the improvements introduced in 1978, 1980 and 1981 have been published (Moody 1979; Raske and Clarke 1982; Raske et al. 1982). To date the basic method consists of delineating damaged areas by percent mortality classes on topographic maps (scale 1:50,000) during a survey by helicopter and then transferring these boundaries to forest inventory maps (scale 1:30,000) or to the most recent colored aerial photographs (scale 1:12,500). Each stand in damaged areas was then assigned a volume-per-ha figure from inventory data or from photo-interpretation. Applying the percent mortality figure from the aerial survey, and summing the area, living and dead volume, for each stand then yielded the totals for the management units. Stands whose trees are almost all blown down are segregated and tallied. Percent damage was checked by ground plots and modified, when necessary. In 1982 the location of the ground plots was precisely marked on aerial photography, to ensure that the damaged stand could be identified on the inventory map, and that the plots can be revisited in future years.

The total area and volume of merchantable stands damaged by the spruce budworm have been recorded annually each year since the beginning of damage to our forests. Therefore cumulative damage figures are available (Table 5). Damage has occurred in 469 000 ha and has affected stands containing 48 674 000 m^3. Of this stand volume, 21 076 000 m^3 has been killed and 1 584 000 m^3 would be classed as moribund.

Not all of this cumulative volume is currently present on forested land, some has been removed by salvage logging, some has burned and some has been blown down. A series of tables has been prepared that show what has happened to our damaged stands and what remains for salvage. The data and tables are related to each other as follows:

1. Total cumulative damage (Table 5) less damaged stands salvaged (Table 6) less damaged stands burned by wildfire (Table 7) less stands classed NSR plus other stands removed from inventory (Table 8)

less damaged stands blown down; not salvable (Table 9) equals Existing damaged stands (Table 10)

2. Existing damaged stands (Table 10) less stands dead for 5 years or more (Table 11) equals damaged stands currently salvable (Table 12)

Table 5. Total cumulative area and volume of productive merchantable stands where tree mortality caused by the spruce budworm was evident in Newfoundland in 1982.

	Damage Category*			
	A (dead)	B (moribund)	C (very severe)	Total
Total Area (ha)	198 000	191 000	81 000	469 000
Dead Volume (m^3)	14 130 000	5 844 000	1 102 000	21 076 000
Dying Volume (m^3)	634 000	729 000	221 000	1 584 000
Stand Volume (m^3)	20 395 000	19 808 000	8 471 000	48 674 000

*A (Dead): 50% or more of total volume of stand dead.

B (Moribund): 20-49% of total volume dead or more than 50% of total volume dying (dying = > 80% total defoliation).

C (Very Severely Damaged): 5-19% of total volume dead or less than 50% of total volume dying.

D (Severely Damaged): Severe damage to trees but less than 5% of total volume of trees dead or dying.

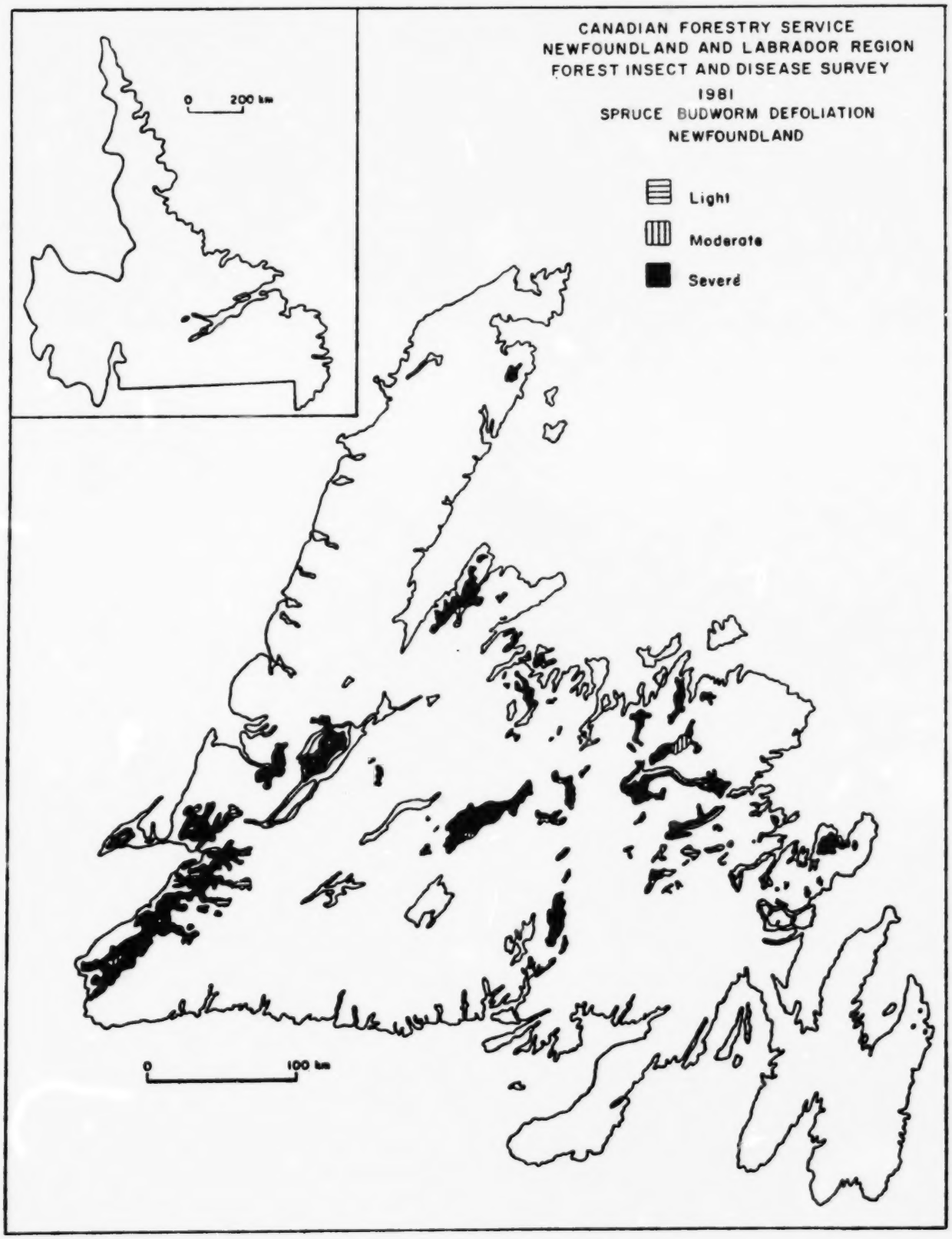


Figure 3. Areas of light, moderate and severe spruce budworm defoliation in newfoundland in 1981.

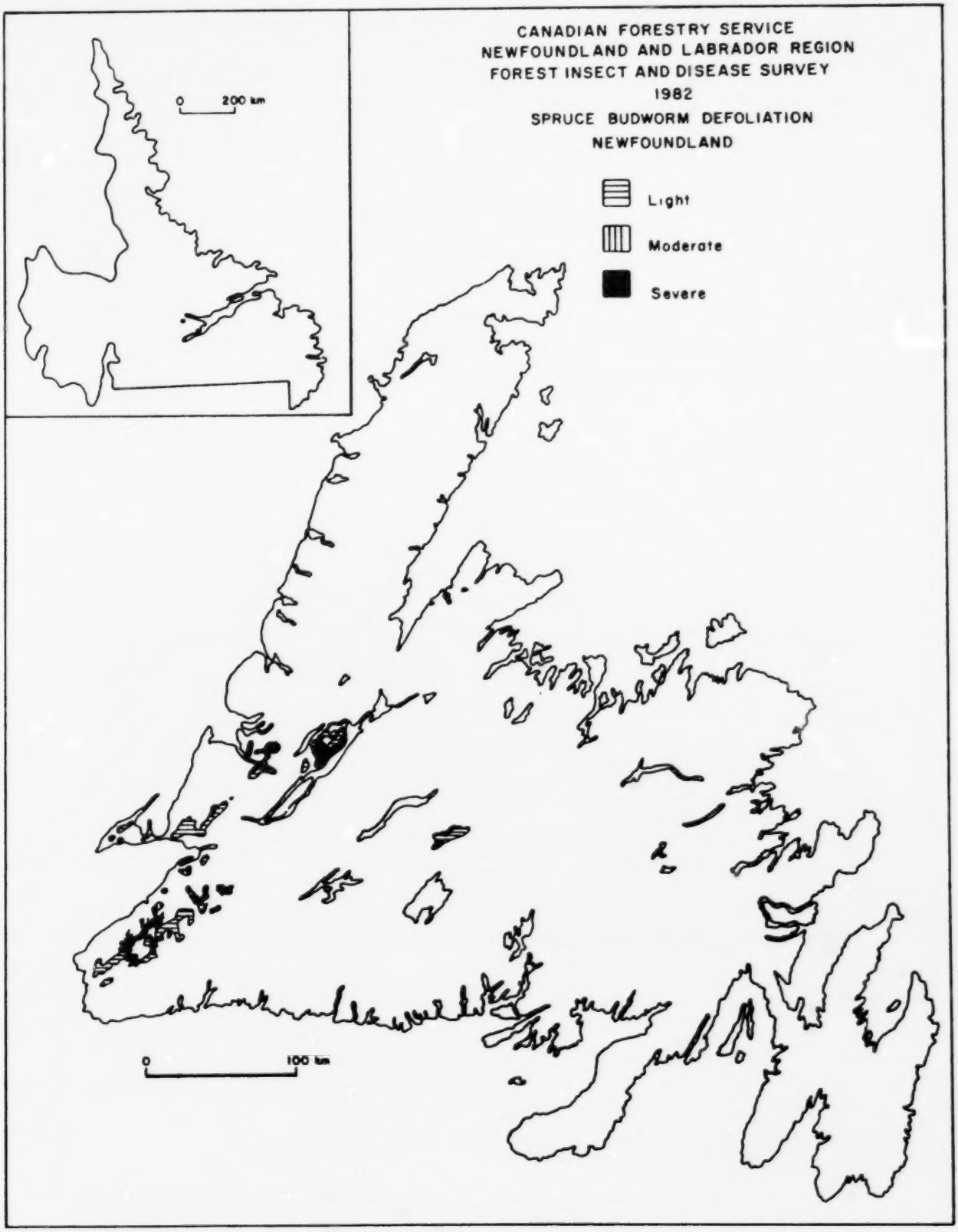


Figure 4. Areas of light, moderate and severe spruce budworm defoliation in Newfoundland in 1982.

Salvage of damaged stands has been in progress since 1978, and 45 000 ha have been logged to date containing 2 113 000 m^3 of dead trees (Table 6). Also, wild fires have burned through damaged stands removing 239 000 m^3 of dead trees in 6 000 ha of merchantable timber (Table 7).

Table 6. Areas and volumes of budworm damaged stands in Newfoundland salvaged by 1982.

	Damage Category*			
	A (dead)	B (moribund)	C (very severe)	Total
Total Area (ha)	17 000	20 000	8 000	45 000
Dead Volume (m^3)	1 324 000	665 000	141 000	2 130 000
Dying Volume (m^3)	157 000	260 000	107 000	524 000
Stand Volume (m^3)	1 573 000	1 832 000	807 000	4 212 000

*For definition of categories see footnote of Table 5.

Table 7. Areas and volumes of budworm damaged stands in Newfoundland destroyed by wildfire by 1982.

	Damage Category*			
	A (dead)	B (moribund)	C (very severe)	Total
Total Area (ha)	2 000	4 000	0	6 000
Dead Volume (m^3)	116 000	123 000	0	239 000
Dying Volume (m^3)	37 000	34 000	0	71 000
Stand Volume (m^3)	166 000	396 000	0	562 000

*For definition of categories see footnote of Table 5.

The volume on productive forest land with more than 75% of the trees dead when the area was last inventoried were classed as NSR (Not Sufficiently Restocked; stands in need of regeneration), as they were considered not salvageable by forest industries. These stands are available for domestic cutting, but their volumes do not enter into annual-allowable-cut calculations for forest management. Therefore, it was decided to produce a set of tables showing the data of NSR stands (Table 8) and the areas and volumes of damaged stands that have blown down and are not commercially salvageable.

Table 8. Areas and volumes of budworm damaged stands in Newfoundland classed as NSR (= Not Sufficiently Restocked) in 1982 stands.

	Damage Category*			
	A (dead)	B (moribund)	C (very severe)	Total
Total Area (ha)	36 000	0	0	36 000
Dead Volume (m^3)	3 588 000	0	0	3 588 000
Dying Volume (m^3)	0	0	0	0
Stand Volume (m^3)	3 588 000	0	0	3 588 000

*For definition of categories see footnote of Table 5.

A total of 36 000 ha was classed as NSR stands (Table 8). The volume on these areas averaged 90% dead for more than five years, or more than 75% had blown down. The volume of 3 588 000 m^3 on these areas is therefore considered unsalvageable for industrial use. Industrial salvage logging would also destroy much of the regeneration that exists in stands.

Furthermore, an additional 21 000 ha were classed during the damage assessment as blown down and unsalvageable (Table 9), leaving an area of 361 000 ha of damaged stands existing on forested land (Table 10). These stands contain 38 138 000 m^3 of trees of which 12 943 000 m^3 are dead and 1 584 000 m^3 are dying. These are the merchantable volumes currently on the productive forests of Newfoundland.

The most important estimate of budworm damage, from a forest management point of view, is the total stand volume containing damaged trees, because salvage operations harvest the whole stand, as partial

Table 9. Areas and volumes of budworm damaged stands in Newfoundland that have blown down and were not salvageable by 1982.

	Damage Category*			
	A (dead)	B (moribund)	C (very severe)	Total
Total Area (ha)	21 000	0	0	21 000
Dead Volume (m^3)	2 174 000	0	0	2 174 000
Dying Volume (m^3)	0	0	0	0
Stand Volume (m^3)	2 174 000	0	0	2 174 000

*For definition of categories see footnote of Table 5.

Table 10. Existing areas and volumes of productive merchantable stands where tree mortality by the spruce budworm was evident in Newfoundland in 1982.

	Damage Category*			
	A (dead)	B (moribund)	C (very severe)	Total
Total Area (ha)	122 000	167 000	73 000	361 000
Dead Volume (m^3)	6 916 000	5 064 000	963 000	12 943 000
Dying Volume (m^3)	632 000	736 000	216 000	1 584 000
Stand Volume (m^3)	12 884 000	17 585 000	7 669 000	38 138 000
	Percent of Stand Volume			
Percent Dead Volume	54	29	13	34
Percent Dying Volume	5	4	3	4
Percent Dead and Dying Volume	59	33	16	38

*For definition of categories see footnote of Table 5.

harvesting is economically and silviculturally unfeasible. The amount of dead wood in these existing stands increased mainly because of the increased dead black spruce. A total of 1 584 000 m^3 was judged to be dying (= more than 80% of its total foliage removed), a decrease from 2 820 000 m^3 in 1981. The volume of dying trees is expected to decrease annually, as these moribund trees will either die or recover.

The existing damaged stands (Table 10) contains some standing volume that is not salvable because it has been dead for more than five years and has deteriorated. This volume is scattered among damaged stands and therefore no area estimate is given for it (Table 11). However, an estimated 3 241 000 m^3 is considered unsalvageable and not available.

Table 11. Standing areas and volumes of budworm-damaged merchantable stands in 1982 that are unsalvable because they have been dead five years or more.

	Damage Category*			
	A (dead)	B (moribund)	C (very severe)	Total
Total Area (ha)	-	-	-	-
Dead Volume (m^3)	319 000	2 445 000	477 000	3 241 000
Dying Volume (m^3)	-	-	-	-
Stand Volume (m^3)	319 000	2 445 000	477 000	3 241 000

This leaves a total stand volume of 34 897 000 m^3 on 361 000 ha that is salvable. These damaged stands contain 9 702 000 m^3 of budworm killed timber and 1 584 000 m^3 is considered moribund (Table 12). Most of this salvable volume will not be salvaged before it deteriorates (Raske and Sutton 1982).

The size of the areas of damaged stands, and also the volumes they contain, are larger in 1982 than the corresponding figures for 1981. This increase was caused by the unexpected increase in spruce mortality within black spruce stands. Previous to 1982 black spruce comprised only 5% of the total tree mortality caused by the budworm. This dead spruce was primarily scattered within severely damaged balsam fir stands; except for several spruce stands between Badger and Springdale. However, in

Table 12. Salvable areas and volumes of productive merchantable stands where tree mortality by the spruce budworm was evident in Newfoundland in 1982.

	Damage Category*			
	A (dead)	B (moribund)	C (very severe)	Total
Total Area (ha)	122 000	167 000	73 000	361 000
Dead Volume (m^3)	6 597 000	2 619 000	486 000	9 702 000
Dying Volume (m^3)	632 000	736 000	216 000	1 584 000
Stand Volume (m^3)	12 565 000	15 140 000	7 192 000	34 897 000
	Percent of Stand Volume			
Percent Dead Volume	47	21	3	28
Percent Dying Volume	4	5	4	5
Percent Dead and Dying Volume	51	26	7	32

*For definition of categories see footnote of Table 5.

late 1982 many stands began to die in black spruce areas. This increase is reflected in the area figures, and occurred in central Newfoundland (compare Fig. 5 with Fig. 6) where also the damaged black spruce stands are.

The number of years since death was recorded in all 975 plots placed in merchantable damaged stands. As in previous years every dead tree in the prism sweep was examined. In 1982, 22% of the dead trees in salvable stands had been dead for six years or more, and 3%, 8%, 10%, 11% and 17% had been dead for five, four, three, two and one year respectively. The 17% dead for one year (down from 31% in 1981) is still high and is evidence that budworm caused mortality is still occurring.

As in previous years immature damaged stands were classed by number of stems affected as follows:

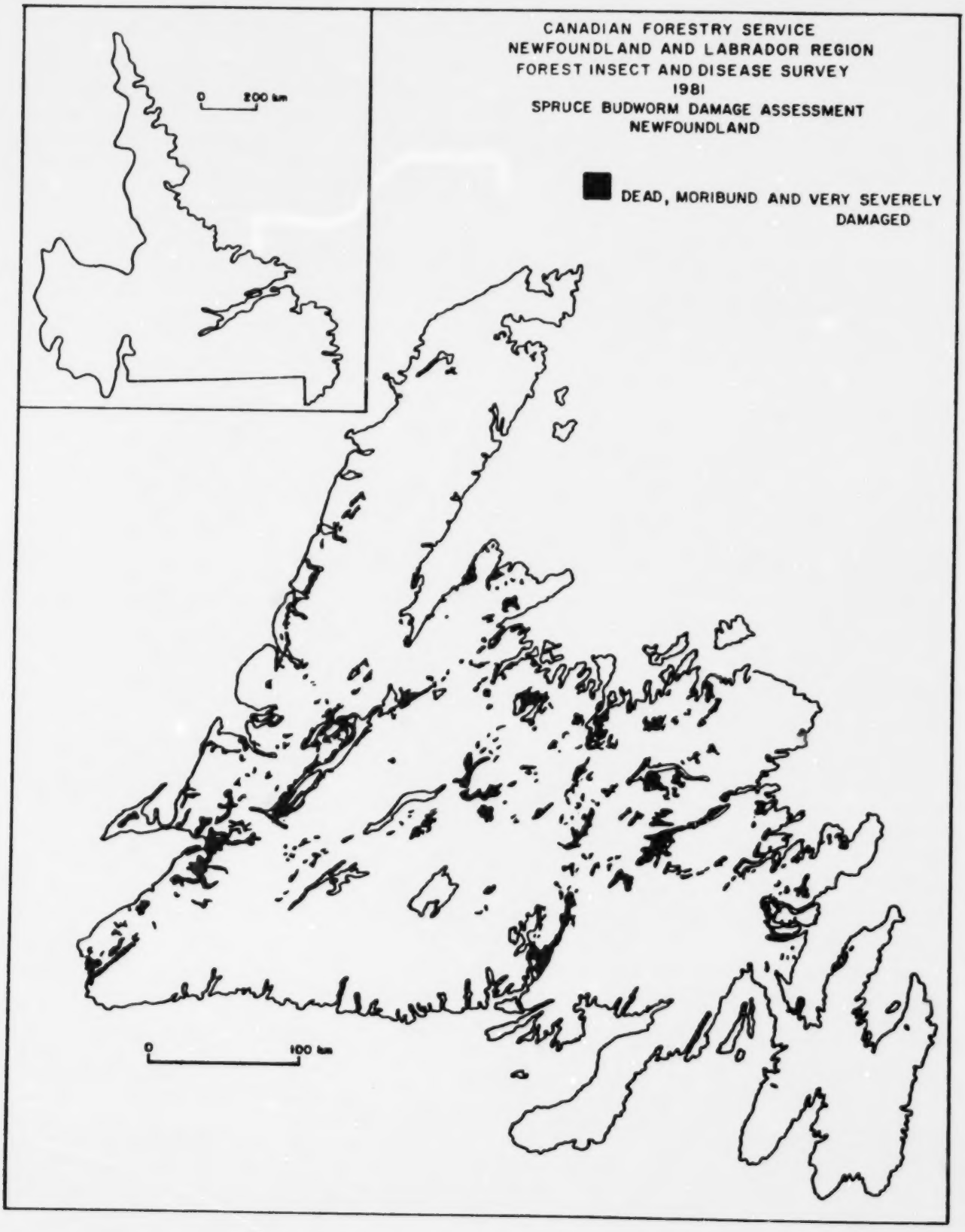


Figure 5. Areas of dead, moribund and very severely damaged stands in Newfoundland in 1981.

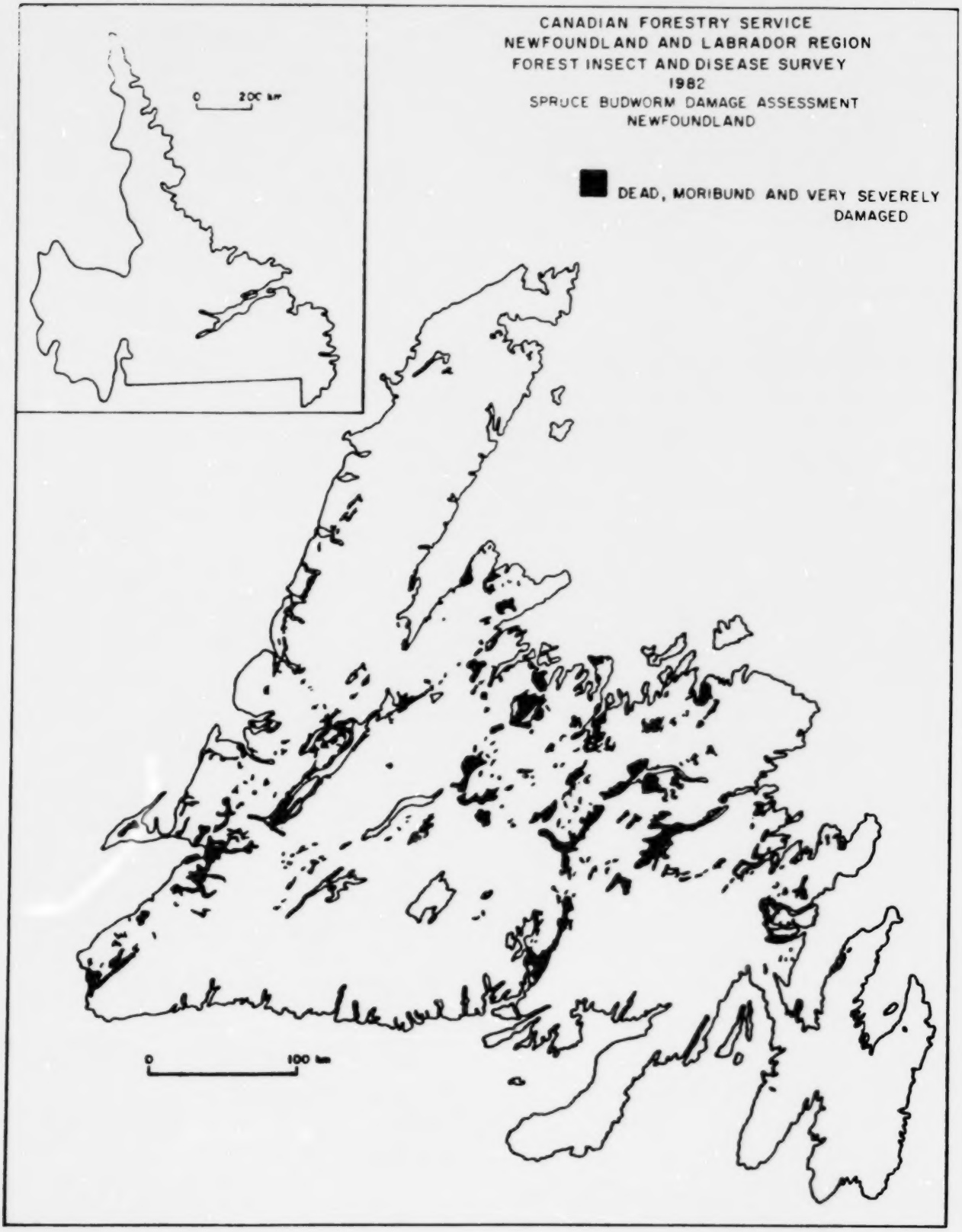


Figure 6. Areas of dead, moribund and very severely damaged stands in Newfoundland in 1982.

a - 50% or more of total stems in stand dead.

b - 20-49% of total stems dead or more than 50% of total stems dying (dying = > 80% total tree defoliation).

c - 5-19% of total stems dead or less than 50% of total stems dying.

The total area of severely damaged immature stands, classes a, b and c, were more precisely mapped in 1982 than in previous years. Both aerial photographs and inventory maps were used to exclude nonproductive areas previously included. Also, some areas have been reclaimed and planted. Therefore, the total damaged areas reported decreased from 77 200 ha in 1981 to 65 000 ha in 1982 (Table 13). There were no new areas of mortality. The average percent of dead stems within areas classed a was 76%, 50% for b areas and 18% for c areas, all increases in percent reported for 1981; 71%, 28% and 7% respectively. Again this increase in percent was caused by more precise delineation of damaged areas and not by an increase in mortality.

Table 13. Areas in ha of productive sub-merchantable stands where tree mortality was evident in Newfoundland in 1982.

Prov. management unit	Areas (ha) by Damage Categories			
	a	b	c	Total
1	0	0	0	0
2	*	400	200	600
3	0	0	0	0
4	3 800	1 500	700	6 000
5	100	1 600	*	1 700
6	6 400	1 400	2 900	10 700
7	1 800	1 000	200	3 000
8	1 600	*	*	1 600
9	900	800	1 100	2 800
10	4 400	700	100	5 200
11	6 600	700	800	8 100
12	*	100	300	400
13	0	0	0	0
14	5 200	13 000	3 500	21 700
15	600	900	600	2 100
16	100	200	100	400
17	400	100	0	500
18	0	0	0	0
Total	31 900	22 400	10 500	64 800

*Less than 50 ha.

III. THE SPRUCE BUDWORM SPRAY PROGRAM IN 1982

a) Spray Operations

The Newfoundland Department of Forest Resources and Lands initiated an operational control program against the spruce budworm in 1982, to protect 96 016 ha with chemical or biological sprays (Carter 1982). A total of 91 708 ha was to receive two applications of the chemical insecticide aminocarb (= Matacil) and 4 308 ha a single application of Bacillus thuringiensis (= B.t. in the formulation labelled "Thuricide 16B".

Pre-spray sampling for budworm numbers proceeded as planned and many areas had lower population levels than anticipated from fall sampling. As a result these areas were deleted from the program and two small areas were added. A total of 47 834 ha were sprayed with Matacil and 4 725 ha with B.t. About 97% of the area treated with chemicals received the prescribed double application of the dosage rate of 70 g per 1.46 ℓ of formulation per ha per application. The prescribed rate of B.t. was a single application of 20 BIU per 7.0 ℓ of formulation per ha.

Spraying was done by two teams of Gruman AgCats, of four planes each, with standard boom and nozzle spray equipment. Spraying began on June 22 and was completed on July 15. Spray blocks were generally quite small, less than 1 500 ha, with the largest area being 4 530 ha. Most spray areas were located in western Newfoundland (Fig. 7) with a few blocks near Gander and near Bay d'Espoir.

Carter (1982) reported reduced budworm numbers in spray blocks generally exceeding 90%, and also considerable lower defoliation (86% reduction) within spray blocks than was expected from pre-spray counts. Population levels within spray blocks was very variable before and after the spray, and precise estimates were not possible. Though not specifically mentioned by Carter (1982) the usual control blocks were not possible because all high populations of the budworm were sprayed, and no high populations outside the spray blocks were found. Therefore, spray and control blocks could not be compared.

b) Environmental Monitoring

Environmental monitoring in 1982 was done under the auspices of the Newfoundland Department of Environment and it had four goals: (1) to assess the short-term impact of the 1982 chemical spray and terrestrial arthropod populations; (2) to assess the short-term and long-term effect of Matacil on bird population age and structure; (3) to assess the short-term impact on aquatic habitats; and (4) to determine how long Matacil residues remain in the environment. Different sampling methods were used to accomplish the various purposes (Anon. 1983a).

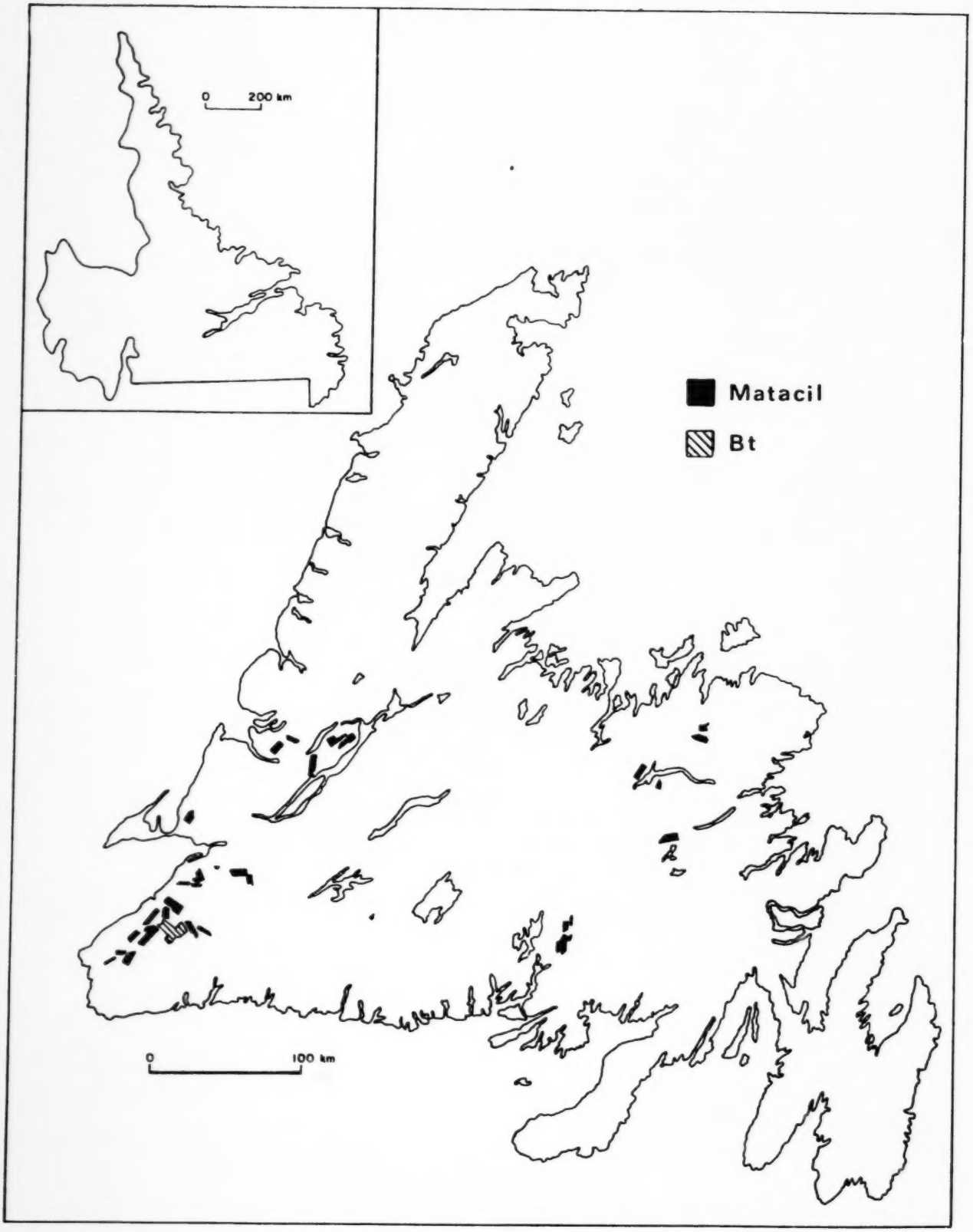


Figure 7. Areas sprayed with Matacil and B.t. in Newfoundland in 1982.

The study and control areas were near Gander, and has been the same area studied every year since 1978. In general wet, cool weather was far more prevalent in June of 1982 than in most years and hampered most studies and may have led to anomalous results in both spray and non-spray areas.

The total number of living terrestrial arthropods on foliage of hardwood and softwood species did not differ significantly between spray and control areas in total biomass nor in the composition of major groups. The total number of dead insects falling onto 1 m^2 trap surfaces differed in spray from control areas. In the sprayed areas the number of dead insects rose sharply the first and second day after the spray, but then continued at pre-spray levels, which were the same levels as in the control areas. The dead insects were mostly short-lived Diptera (two-winged flies) that frequently use bushes and trees as resting places. By the end of the sampling period differences between spray and non-spray areas could not be detected.

In 1982 bird population age and structure were intensively studied. No conclusions could be drawn from the extensive data collected. The unusual weather may have had a greater effect than the spray program.

As in the past, Matacil residue levels in aquatic habitats always decreased to non-detectable levels within 48 hours, and usually within 24 hours. Usually an increase in drift of macro-invertabrates occurs immediately after the spray. However, in 1982 no measurable increase in drift occurred compared to that in the control areas. The similar increase in both areas may have been a natural seasonal phenomenon, unrelated to the spray. No differences in algal biomass was recorded.

Detectable levels of Matacil residues occurred in the terrestrial environment up to 28 days after spraying. However, four out of 18 samples in the control areas also had detectable levels of Matacil. Contamination was ruled out and the reason for the positive readings in these samples is not known.

IV. FORECAST OF BUDWORM INFESTATIONS FOR 1983

The invasion of spruce budworm moths from New Brunswick to Newfoundland in 1982 (Dobesberger et al. 1983) prompted the Forest Insect and Disease Survey to survey for budworm egg-masses across the Island, even in areas where local infestations had collapsed in 1981 and 1982. A total of 822 locations were sampled on the Island and 20 locations in Labrador. A total of 155 locations were in black spruce and the remainder in balsam fir. The branches of 113 locations were washed in a

sodium hydroxide solution to obtain estimates of overwintering larvae. As in past years sample locations were concentrated in western and central Newfoundland (Appendix VIII). All of the egg-mass samples were recounted by a second person.

The area of moderate and severe defoliation forecast for 1983 is 110 300 ha and an additional areas of 101 500 ha is forecast to be lightly defoliated for a total of 211 800 ha (Table 14, Fig. 8). Moderate and severe defoliation is distributed in isolated patches from the Codroy Valley to the Humber Canal near Deer Lake in western Newfoundland, and along Noel Paul's Brook in central Newfoundland. Patches of light defoliation are expected adjacent to more severe defoliation and also on the Northern Peninsula, near Twin Lakes and other scattered locations in central Newfoundland, and on the Bonavista and Avalon Peninsula in eastern Newfoundland (Fig. 8). Two small areas of defoliations, both near Goose Bay, are expected in Labrador.

The area of moderate to high hazard forecast for 1983 was about 165 000 ha (Table 14). Most areas of high hazard, meaning high probability of some tree mortality in the area, occurred in western Newfoundland near Corner Brook, near Stephenville and in the Codroy Valley (Fig. 9).

A total of 91% of the branches sampled had no egg-masses nor overwintering larvae, and 50% of the samples occurred in areas forecast to have light defoliation. In 1981 the proportion of samples without egg-masses was 89%, and it was 56%, 57%, 51% and 31% in 1980, 1979, 1978 and 1977 respectively.

The average number of egg-masses per 10 m^2 of foliage for all localities has been used as an index of spruce budworm population levels (Table 15). This index, averaged for all regions, was greater than 90 before 1980, and dropped to 14 in 1981, and to seven in 1982. However, those few sample locations with sufficient egg-masses to forecast moderate and severe defoliation, had about as many egg-masses per 10 m^2 of foliage in 1982 as in previous years (Table 16).

Spruce budworm damage hazard areas were delineated for 1982 from egg-mass and overwintering larval surveys, from severity of current and previous year's defoliation, and from tree vigor data. Ratings for each factor in the hazard rating system are given in Appendix VII. Moderate to high hazard indicates tree vigor will be further reduced and some top killing and tree killing can be expected. Moderate to high hazard, i.e. damaged areas with expected budworm populations in 1983, are expected in about 165 000 ha in 1983 (Table 14, Fig. 8) on the Island, and about 1 000 ha in Labrador.

Table 14. Areas of light, moderate and severe defoliation, and moderate and high hazard forecast in productive forests of Newfoundland for 1983.

Management unit no.	Ownership	Area of Defoliation (ha)		Areas of moderate and high hazard (ha)
		Light	Moderate and severe	
1	Crown	5 200	-	-
2	Crown	2 500	-	1 200
7	Bowater	1 700	-	1 700
8	Crown	1 000	-	1 000
9	Bowater	1 600	-	1 200
10	Abitibi	2 200	-	2 200
11	Abitibi	7 800	-	5 900
12	Abitibi	2 000	12 900	12 900
13	Abitibi	900		
14	Crown	29 200	5 300	28 000
14	Bowater	19 200	36 200	52 500
15	Crown	300	-	300
15	Bowater	11 500	54 500	54 400
16	Bowater	1 300	-	-
17	Bowater	5 400	-	-
18	Bowater	8 600	-	1 900
19	Crown (Labrador)	100	1 100	1 100
TNNP		400	400	400
GMNP		600	-	-
All	Crown	38 200	6 300	31 600
	Bowater	49 300	90 700	111 700
	Abitibi	12 900	12 900	21 000
	TNNP	400	400	400
	GMNP	600		
Total Island		101 400	109 300	164 700
Total Labrador		100	1 000	1 100

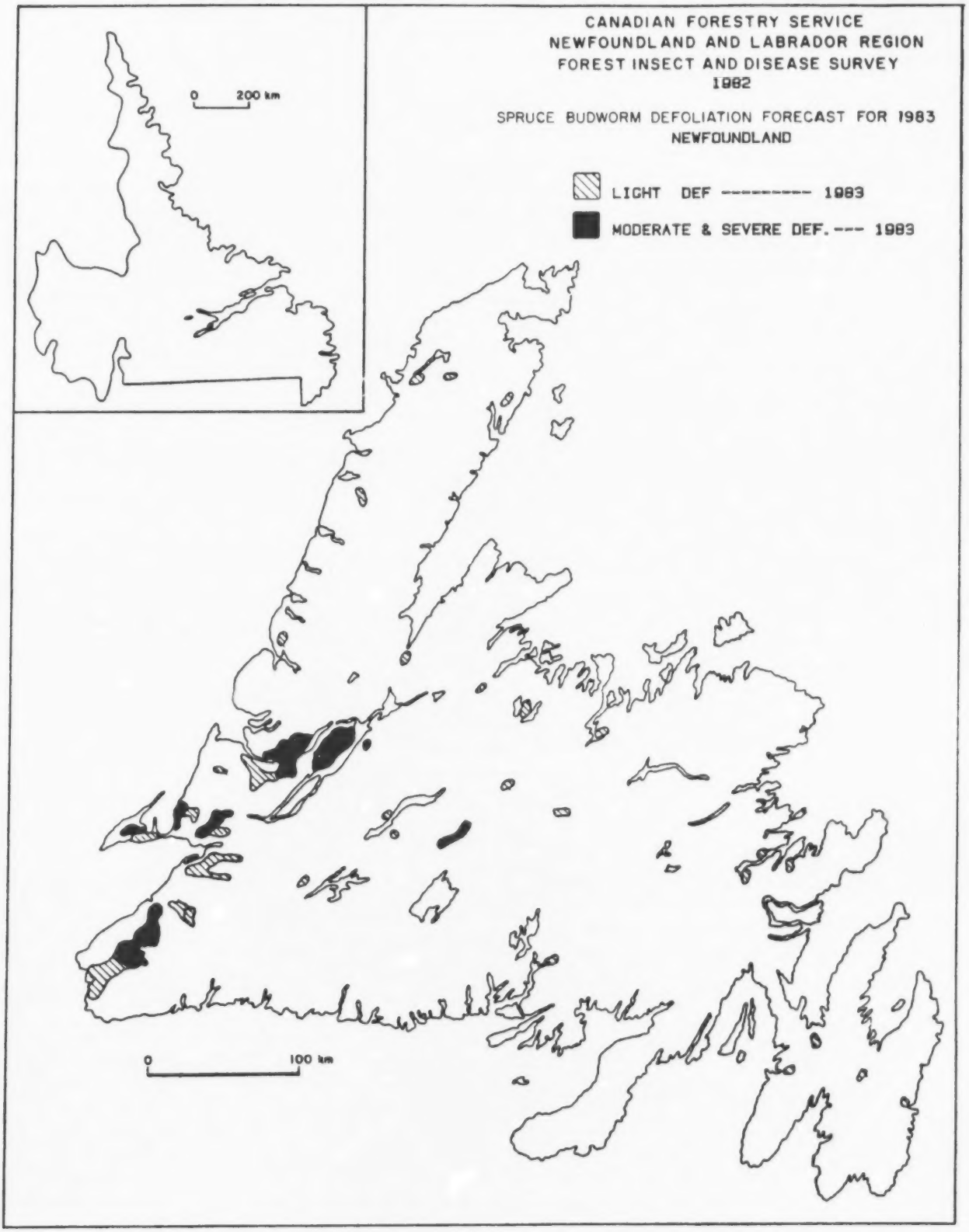


Figure 8. Areas of light, moderate and severe defoliation by the spruce budworm forecast in Newfoundland for 1983.

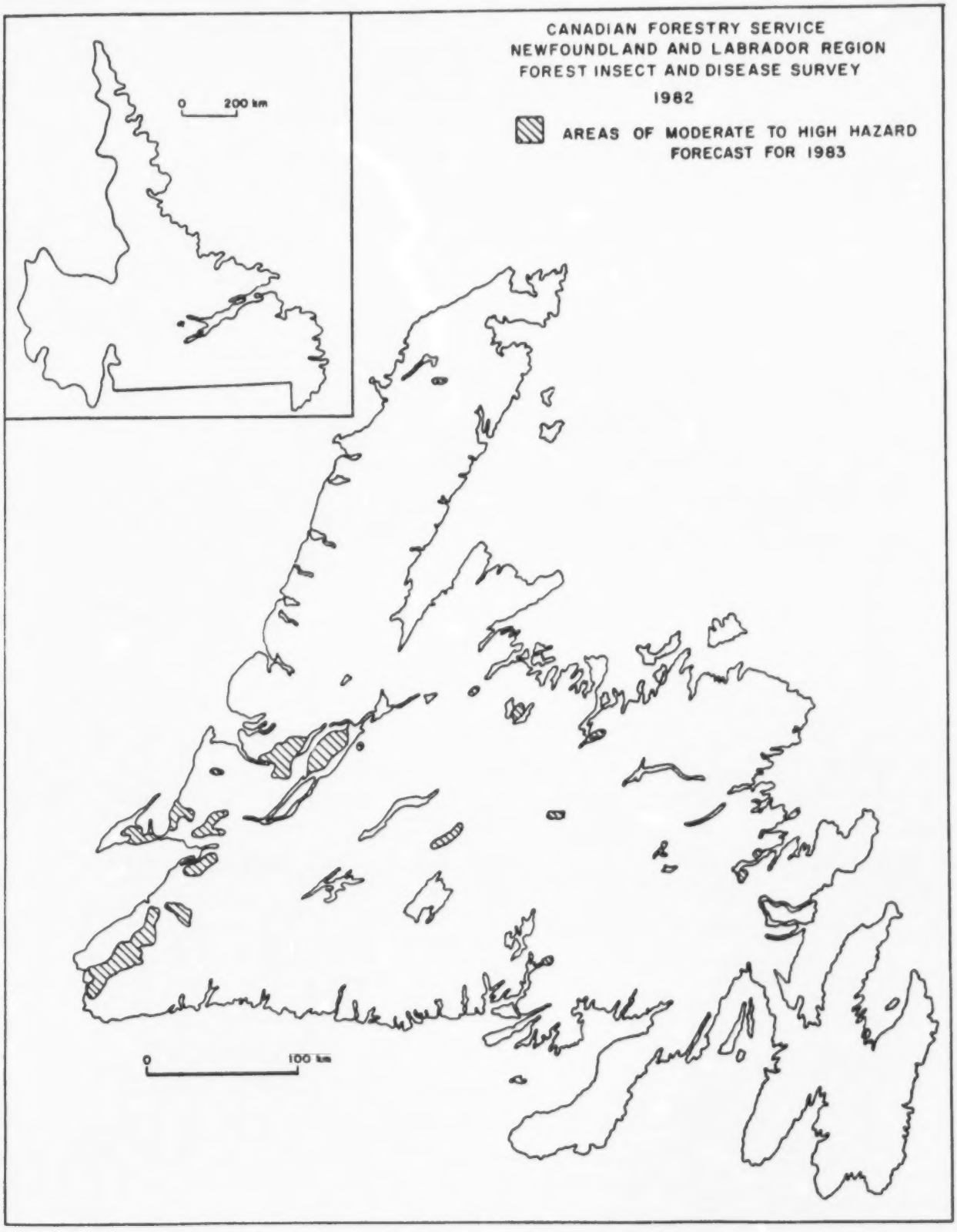

CANADIAN FORESTRY SERVICE
NEWFOUNDLAND AND LABRADOR REGION
FOREST INSECT AND DISEASE SURVEY
1982
AREAS OF MODERATE TO HIGH HAZARD FORECAST FOR 1983
0 200 km
0 100 km

Figure 9. Areas of moderate and high hazard from spruce budworm defoliation forecast in Newfoundland for 1983.

Table 15. Average number of spruce budworm egg-masses per 10 m^2 of foliage from 1977 to 1982 in three regions in Newfoundland and Labrador.

	Mean Number of Egg-masses Per 10 m^2 Per Location							
	1977				1978			
Region	No. of samples	Mean	S.D.	Range	No. of samples	Mean	S.D.	Range
Western	432	92	181	0-1559	393	29	82	0-575
Central	315	204	296	0-2178	301	138	242	0-2255
Eastern	172	412	654	0-5080	160	192	243	0-1120
Total or weighted average	919	190			854	98		
	1979				1980			
Western	429	24	91	0-929	370	62	208	0-2308
Central	327	121	185	0-1222	291	97	195	0-2308
Eastern	158	213	237	0-1333	149	166	378	0-4116
Total or weighted average	914	91			810	94		
	1981				1982			
Western	278	8	38	0-453	316	16	-	0-2467
Central	335	9	55	0-833	343	1	-	0-522
Eastern	184	25	92	0-903	163	1	-	0-57
Labrador	10	0	-	-	20	3	-	0-395
Total or weighted average	807	14			842	7		

Table 16. Summary of spruce budworm egg-mass numbers per 10 m^2 of foliage for sample points with moderate and severe defoliation forecast in Newfoundland from 1978 to 1982.

Year	Moderate Defoliation Forecast*		Severe Defoliation Forecast*	
	No. sample points	Avg. EM/ 10 m^2	No. sample points	Avg. EM/ 10 m^2
1978	72	154	124	491
1979	65	149	149	438
1980	49	149	123	437
1981	4	129	4	440
1982	10	147	7	379

*Sequential limits for spruce budworm egg-masses/10 m^2 used for predicting defoliation:

No. of branches	Cumulative Number of Egg-Masses/10 m^2		
	Light**	Uncertain (moderate)	Severe
1	-	0-337	> 337
2	< 148	149-505	> 505
3	< 315	315-672	> 672

**Class limits of defoliation used for forecasting:

Nil = 0%
Light = 1-25%
Moderate = 26-75%
Severe = 76-100%.

V. SUMMARY AND CONCLUSIONS

A total of 20 600 ha was expected to be moderately and severely defoliated in 1982 in Newfoundland, and a total of 71 300 ha was in the moderate to high hazard category. Cool and wet weather prevailed in May and June and initiation of larval feeding was delayed by two to three weeks compared to normal. Larval survival was normal but a drastic decrease in population levels occurred between the sixth larval instar and the pupal stage. The cause of the decrease in not known.

Combined larval and pupal parasitism was about 11%. Approximately 14% were diseased, 6% of laboratory-reared larvae died of unknown causes, 1% died in rearing and 68% emerged as adults.

The total area of light, moderate and severe defoliation in productive forests of the Island was about 90 000 ha, of which 41 000 ha were in the moderate and severe categories.

The total cumulative area of merchantable stands containing dead and dying trees was 469 000 ha. Some stands have been salvaged, others burned, some removed from forest inventory, others have blown down, and some have been dead for more than five years and are therefore unsalvable. This leaves 361 000 ha of stands that contain more than 10% mortality caused by the budworm.

The total cumulative stand volume of existing merchantable softwood stands containing dead and dying trees was 48 674 000 m^3, of which 21 076 000 m^3 were dead and 1 584 000 m^3 were dying. From these estimates, volumes of salvaged, burnt or wind thrown stands were subtracted to arrive at existing volumes of 38 138 000 m^3 of total stand volume and 12 943 000 m^3 of dead volume. The estimated stand volume of timber still salvable is 34 897 000 m^3 containing 9 702 000 m^3 of dead wood.

Of the timber killed by the budworm, 22% had been dead for six years or more, and 3%, 8%, 10%, 11% and 17% had been dead for five, four, three, two and one year respectively.

The total area of damaged immature stands was estimated at 65 000 ha, an apparent decrease from the 77 200 ha in 1981 which may be explained mainly by more precise mapping and by stand reclamation.

A total of 47 834 ha were sprayed with Matacil and 4 725 ha with B.t. in 1982. A reduced number (90%) of budworm was reported in spray blocks and a reduction in defoliation of 86% was estimated. Environmental monitoring of the spray operation detected no deleterious side effects.

In 1983 moderate and severe defoliation are expected on 110 300 ha, and an additional 102 000 ha is forecast to be lightly defoliated for a total of 212 300 ha. Much of this area has been already severely defoliated and 166 000 ha were classed as moderate to high hazard for 1983.

VII. LITERATURE CITED

Anonymous. 1983a. 1982 Environmental monitoring of the spruce budworm program in Newfoundland. Gov't. Newfoundland, Dept. of the Environment, Final Report, 193 pp.

Anonymous. 1983b. 1981 Environmental monitoring of the spruce budworm spray program in Newfoundland. Gov't. Newfoundland, Dept. of the Environment, Final Report, 107 pp.

Carter, N.E. 1982. The 1982 aerial forest protection program against spruce budworm in Newfoundland. Newfoundland Dep. For. Resour. Lands, For. Prot. Div., Inf. Rep. FP-6, 19 pp.

Dobesberger, E.J., K.P. Lim and A.G. Raske. 1983. Spruce budworm (Lepidoptera: Tortricidae) moth flight from New Brunswick to Newfoundland. Can. Ent. 115:1641-1645.

Dobesberger, E.J. and K.P. Lim. 1983. Population levels and biological mortality factors of spruce budworm in balsam fir stands in Newfoundland during 1982. Environ. Can., Can. For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-218, 18 pp.

Moody, B.H. 1979. Spruce budworm assessment in Newfoundland in 1977 and 1978. Environ. Can., Can. For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-173, 24 pp.

Moody, B.H. 1980. The status of the spruce budworm in Newfoundland in 1979. Environ. Can. For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-190, 41 pp.

Moody, B.H. and I.S. Otvos. 1979. The status of the spruce budworm in Newfoundland in 1978. Environ. Can. For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-171, 35 pp.

Otvos, I.S. and B.H. Moody. 1978. The spruce budworm in Newfoundland: History, status and control. Environ. Can., For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-150, 76 pp.

Raske, A.G. and L.J. Clarke. 1982. The status of the spruce budworm in Newfoundland in 1980. Environ. Can., For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-208, 40 pp.

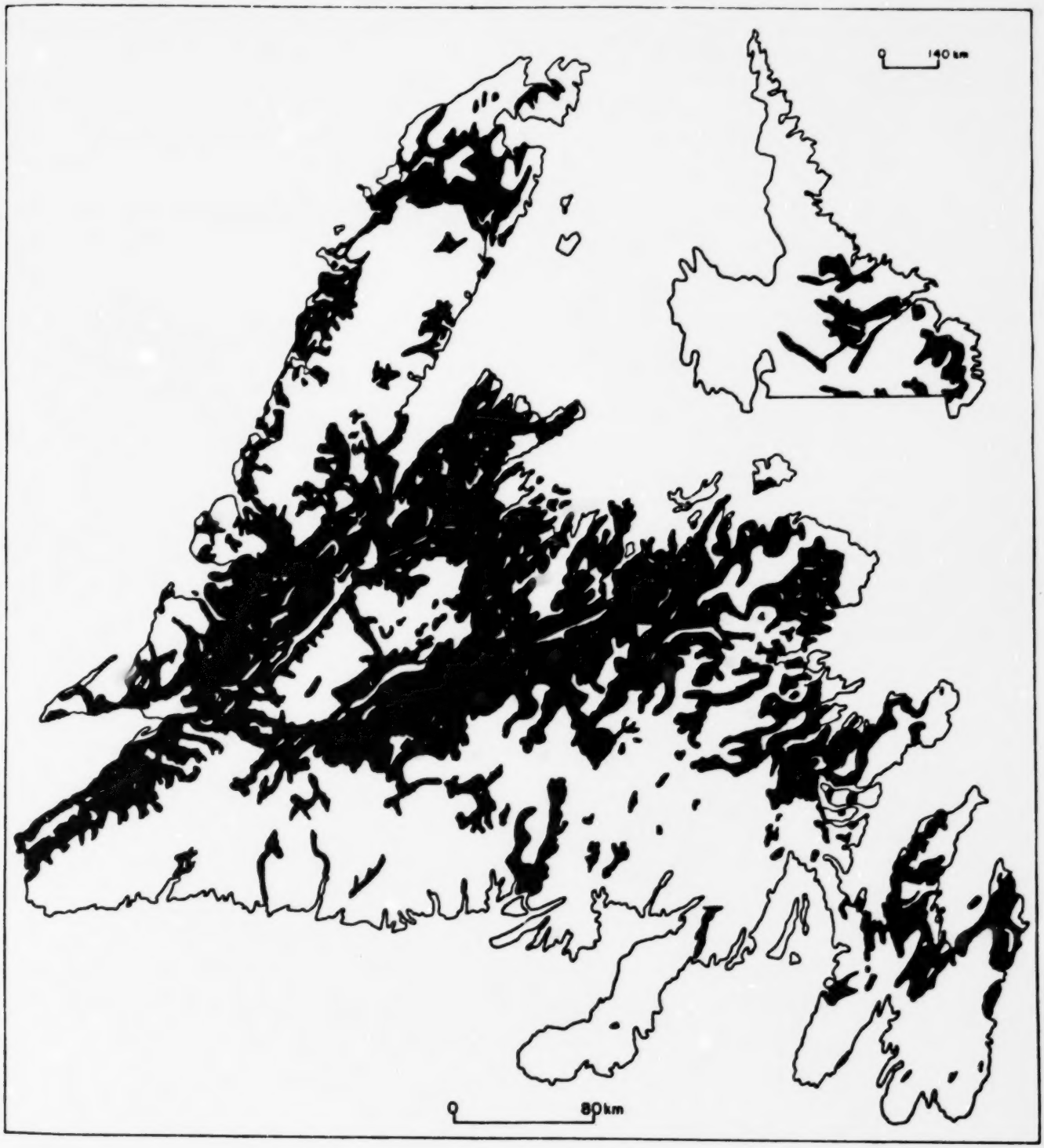
Raske, A.G., L.J. Clarke and W.J. Sutton. 1982. The status of the spruce budworm in Newfoundland in 1981. Environ. Can., For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-210, 49 pp.

Raske, A.G. and W.J. Sutton. 1981. Data recording manual for defoliator damage assessment for conifers in Newfoundland. Environ. Can., For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-197, 23 pp.

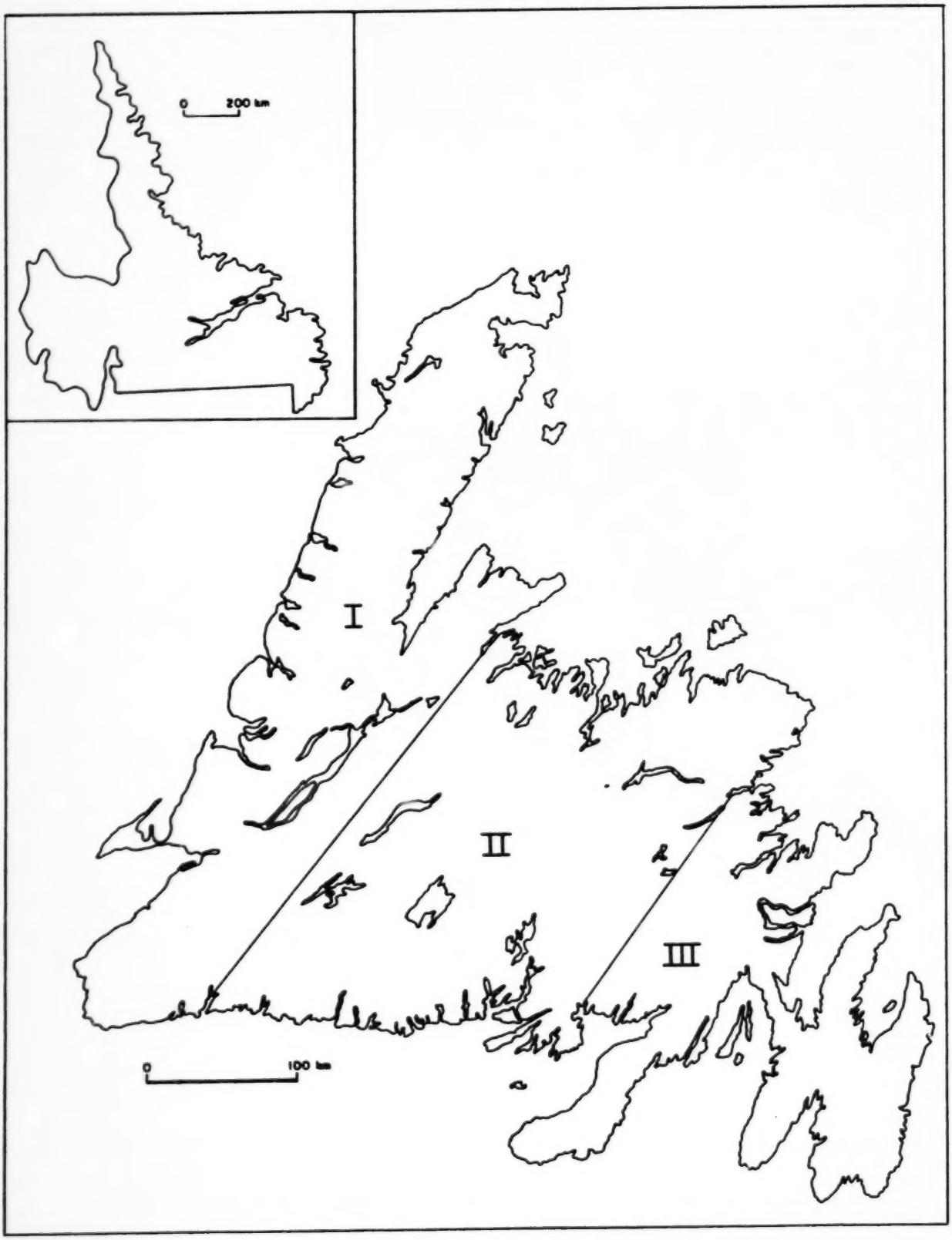
Raske, A.G. and W.J. Sutton. 1986. Decline and mortality of black spruce caused by spruce budworm defoliation and secondary organisms. Can. For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-236, 14 pp.

Sutton, W.J. 1981. Data recording manual for defoliator damage assessment for conifers in Newfoundland. Environ. Can., For. Serv., Newfoundland For. Res. Centre, Inf. Rep. N-X-197, 23 pp.

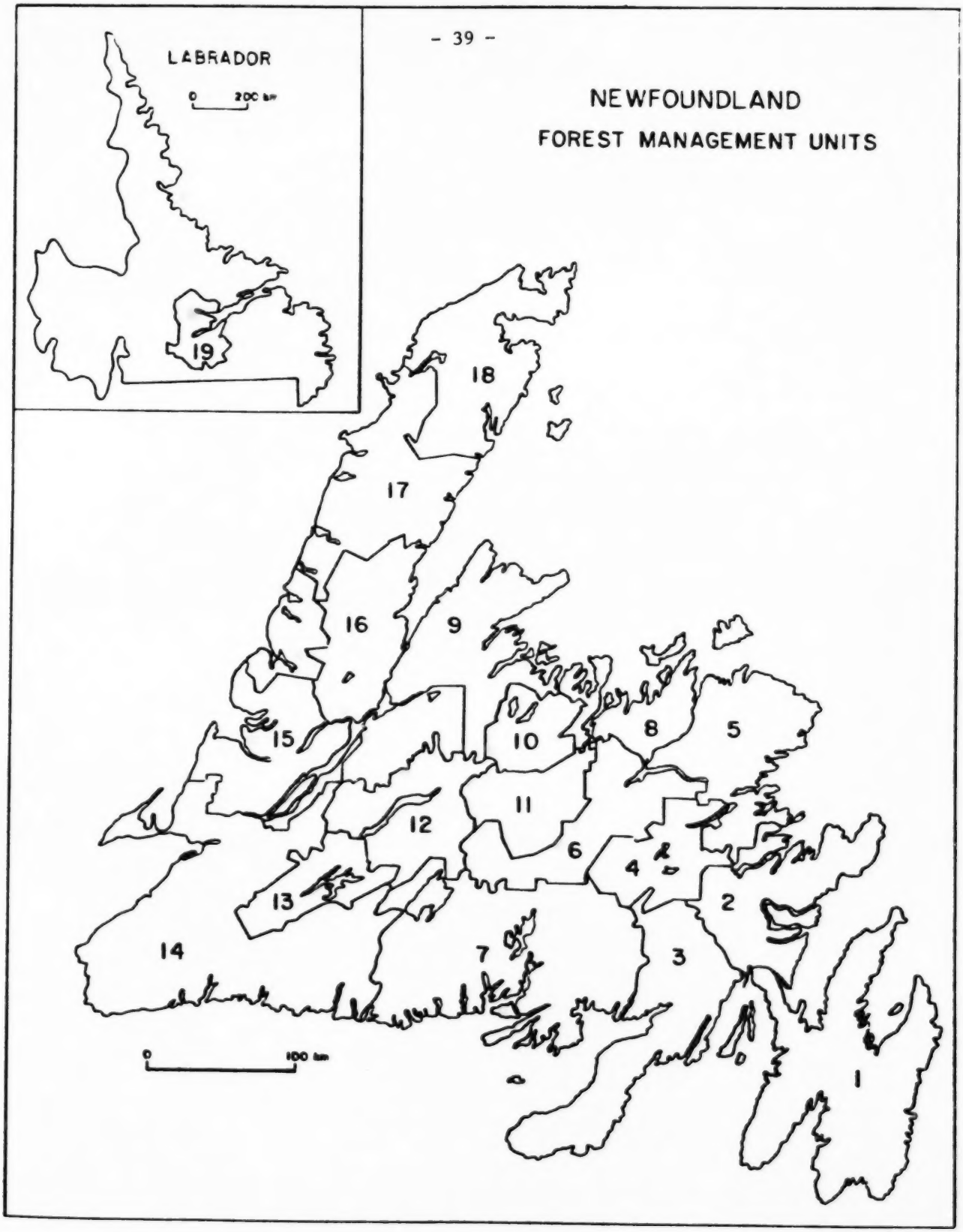
APPENDICES



Appendix I. Productive forest area of Newfoundland and Labrador.



Appendix II. Major geographic regions of Newfoundland and Labrador. (I) western, (II) central, (III) eastern, (IV) Labrador.



Appendix III. Forest management units in Newfoundland and Labrador.

APPENDIX IV

Environmental Monitoring of the 1981 Spruce Budworm Spray Program

The side effects of the Newfoundland spray program is monitored yearly by the Newfoundland Department of the Environment, and a report is produced annually. This report on the monitoring activities of the 1981 spray program was not available in time to be summarized in the status of the spruce budworm for 1981 (Raske et al. 1982). For continuity and completeness, the report of the 1981 monitoring (Anon. 1983b) is summarized here.

In 1981 neither terrestrial nor aquatic communities had spray related mortality levels sufficiently high to result in evident changes in community structure or in severe and prolonged reductions of populations within these communities. However, several insect groups sustained some immediate mortality. Parasitic hymenoptera, spiders and some adult diptera occurred more frequently in traps in sprayed areas than in unsprayed areas. In aquatic communities, certain families among the aquatic Diptera, Ephemeroptera and Trichoptera appeared in drift samples in peaks immediately after the spray, but returned to pre-spray levels within two days. Berthic communities did not appear to be affected.

Aminocarb deposited on vegetation and soil during aerial spraying degraded at satisfactory rates and existed only at trace levels by the end of the summer of 1981. Analysis for aminocarb in wildlife tissues following the 1978 aminocarb spray -- when initial levels on vegetation were higher than in 1981 -- indicated no traces of the active ingredient. Aminocarb introduced into aquatic systems during the spray in 1981 was diminished to non-detectable levels within three to four days.

In an emergency, a pilot jettisoned his load of Matacil west of Gander in late June, however no measurable degree of contamination of water courses occurred.

A serious attempt was made to monitor aminocarb levels of ambient air. Wind conditions were such that very little drift occurred and only occasional traces of he chemical were recorded; near Gander, Norris Arm and Pasadena. Concentrations of the chemical were too low and infrequent to have had a measurable effect.

Many logistical difficulties encountered in the course of the 1981 monitoring of bird communities preclude any reasonable conclusions. However, no obvious detrimental effect on birds was noted, including fledgling survival and activity. Only one consistent difference was detected. The two control areas had significantly higher repeat-catch rate for mist-netted birds, indicating that a netted bird was more likely to be caught a second time. Therefore, it seems that birds in sprayed areas were more mobile, and had a wider search area than in unsprayed areas.

Appendix V. Average number of spruce budworm larvae per FIDS sample in three regions of Newfoundland and in Labrador from 1977 to 1982.

	Beating Samples[1]												Branch Samples									
	No. of trees sampled (locations)[2]						Avg. no. larvae per tree sample						No. branches sampled (locations)[2]					Avg. no. larvae per branch				
Region	77	78	79	80	81	82	77	78	79	80	81	82	78	79	80	81	82	78	79	80	81	82
Western	521	441	331	255	308	111	42	13	22	28	16	15	460	343	82	149	170	3.8	5.6	16	11.2	5.3
Central	135	172	157	143	129	39	144	26	43	69	22	2	69	87	181	140	-	14.1	22.1	8	6.3	-
Eastern	628	259	38	108	59	48	57	25	86	88	10	4	179	204	52	-	-	8.1	13.0	14	-	-
Island	1284 (343)	872 (227)	526 (289)	506 (178)	496 (158)	198 (64)	60	19	33	52	17	10	708 (223)	634 (330)	315 (118)	289 (99)	170 (62)	6.0	10.2	10.9	8.8	2.8
Labrador	50 (17)	4 (2)	51 (17)	- -	- -	6 (2)	29	6	0	-	-	1	-	-	-	-	-	-	-	-	-	-
Total	1334 (360)	876 (229)	577 (306)	-	-	204 (66)	59	19	30	-	-		-	-	-	-	-	-	-	-	-	-

[1]The 2 m x 3 m beating sheet and 1 m x 1 m beating tray.

[2]Number of locations sampled in parentheses.

Appendix VI. Number of egg-mass sample locations by predicted defoliation classes and geographical regions from 1977-82 in Newfoundland and Labrador. Numbers in parentheses are percentages based on total number of sample locations.

Year sampled	Region	No. points sampled	Number of Sample Locations in the Predicted Defoliation Classes			
			Nil	Light	Moderate	Severe
1977	Western	432	165(17.4)	157(16.5)	52(5.5)	58(6.1)
	Central	315	68(7.2)	108(11.4)	42(4.4)	97(10.2)
	Eastern	172	47(5.0)	38(4.0)	11(1.2)	76(8.0)
	Labrador	31	19(2.0)	8(1.0)	2(0.2)	2(0.2)
	Total	950	299(31.6)	311(32.7)	107(11.3)	233(24.5)
1978	Western	393	295(33.9)	70(8.0)	20(2.3)	8(0.9)
	Central	301	100(11.5)	105(12.1)	34(3.9)	62(7.1)
	Eastern	162	40(4.6)	44(5.1)	24(2.8)	54(6.2)
	Labrador	15	11(1.2)	3(0.3)	1(0.1)	0 -
	Total	871	446(51.2)	222(25.5)	79(9.1)	124(14.2)
1979	Western	430	340(36.2)	64(6.8)	15(1.6)	11(1.2)
	Central	327	146(15.6)	68(7.2)	35(3.7)	78(8.3)
	Eastern	160	40(4.3)	31(3.3)	26(2.8)	63(6.8)
	Labrador	21	19(2.0)	2(0.2)	-	-
	Total	938	545(58.1)	165(17.5)	76(8.1)	152(16.3)
1980	Western	370	264(32.6)	60(7.4)	13(1.6)	33(4.1)
	Central	291	166(20.5)	53(6.5)	19(2.4)	53(6.5)
	Eastern	149	52(6.4)	45(5.6)	14(1.7)	38(4.7)
	Labrador	0	-	-	-	-
	Total	810	482(59.5)	158(19.5)	46(5.7)	124(15.3)
1981	Western	278	229(28.4)	44(5.5)	3(0.3)	2(0.2)
	Central	335	311(38.5)	22(2.7)	0	2(0.2)
	Eastern	184	168(20.8)	15(1.9)	1(0.1)	0
	Labrador	10	10(1.2)	0	0	0
	Total	807	718(89)	81(10)	4(0.5)	4(0.5)
1982	Western	316	251(29.8)	50(5.9)	8(0.9)	7(0.8)
	Central	343	336(39.9)	6(0.7)	1(0.1)	-
	Eastern	163	162(19.2)	1(0.1)	-	-
	Labrador	20	18(2.1)	1(0.1)	1(0.1)	-
	Total	842	767(91.1)	58(6.9)	10(1.2)	7(0.8)

Appendix VII. Numerical values of tree conditions and hazard rating system used to forecast losses in spruce budworm infested stands.

1. Current Defoliation

% Defoliation	Hazard rating
0	0
1 - 25	1
26 - 65	2
66 - 95	3
96 - 100	4

2. Old Defoliation or Previous Damage

Category	% Defoliation	Hazard rating
Zero	0	0
Light	1 - 25	3
Moderate	26 - 75	6
Severe	76 - 100	9
Dead tops	-	12 (optional)
Dead trees	-	15 (optional)

3. Tree Vigor

Category	Hazard rating
Dying	0
Poor	-1
Fair	-2
Good	-3

4. Egg-mass/10 m^2 of foliage

Category		Expected defoliation %	Hazard rating
0	Nil	0	0
1 - 106	Light	1 - 30	1
107 - 257	Moderate	31 - 65	2
258 - 429	High	66 - 90	3
430+	Very High	91 - 100	4

5. Sample Point Hazard Rating Categories for the Newfoundland Forest Research Centre

Hazard rating	Range of total values	Remarks
Low	0 - 6	
Moderate	7 - 10	Protection suggested
High	11 - 14	Protection suggested
Very high	15+	Presalvage suggested

Appendix VIII. Total cumulative area and volume of productive merchantable stands by ownership and management unit where tree mortality caused by the spruce budworm was evident in Newfoundland in 1982.

Prov. manag. unit	Owner	Area and Volume Affected											
		A (dead)				B (moribund)				C (very severe)			
		Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)
1	Crown	6	35	27	3	16	92	21	5	4	21	1	1
	Private	-	-	-	-	1	6	1	-	-	5	-	-
2	Crown	-	-	-	-	105	813	174	45	29	242	13	4
4	Crown	-	-	-	-	-	1	-	-	-	-	-	-
	Bowater	-	2	1	-	-	-	-	-	-	-	-	-
	Abitibi	94	876	477	14	20	166	51	7	49	466	58	11
5	Crown	77	794	353	25	4	32	12	-	10	107	10	-
	Bowater	49	516	240	14	-	-	-	-	12	119	11	-
	Abitibi	30	338	260	5	-	-	-	-	2	23	2	-
6	Crown	1	10	6	1	-	2	-	-	-	-	-	-
	Bowater	118	1 411	927	64	216	2 564	888	71	1	11	2	-
	Abitibi	14	152	100	8	2	17	5	1	-	-	-	-
7	Crown	168	1 472	1 065	42	130	1 046	279	78	24	180	33	8
8	Crown	157	1 450	754	37	51	489	116	2	3	49	8	-
	Bowater	29	383	210	12	4	47	11	-	-	-	-	-
	Abitibi	4	41	19	-	3	28	8	-	1	8	1	-
	Private	-	-	-	-	-	-	-	-	-	-	-	-
9	Crown	104	1 116	822	46	69	668	176	29	92	735	19	-
	Bowater	83	930	665	30	252	2 704	746	153	77	550	35	-
	Abitibi	39	416	350	5	32	300	107	1	21	212	23	-
10	Crown	8	78	61	2	27	194	57	4	3	30	4	6
	Abitibi	104	1 017	750	26	175	1 814	554	41	55	573	73	99
11	Bowater	-	-	-	-	3	43	15	1	-	2	1	-
	Abitibi	65	649	486	11	65	653	221	17	75	762	246	68

(Cont'd.)

Appendix VIII. (Concl'd.)

Prov. manag. unit	Owner	Area and Volume Affected											
		A (dead)				B (moribund)				C (very severe)			
		Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)
12	Crown	-	-	-	-	21	226	61	13	-	-	-	-
	Abitibi	68	736	552	12	55	561	121	25	2	17	3	1
13	Abitibi	28	332	236	-	41	477	160	-	4	34	6	-
14	Crown	178	1 865	1 408	38	136	1 360	338	50	40	466	63	-
	Bowater	150	1 687	1 176	44	184	2 362	633	89	112	1 393	190	-
	Abitibi	26	321	168	13	39	517	141	19	63	882	120	-
	Private	11	105	55	4	24	204	51	7	2	30	4	-
15	Crown	64	640	549	25	18	188	71	5	10	121	9	-
	Bowater	173	1 780	1 398	133	96	1 014	383	17	71	843	73	-
	Private	3	32	18	6	-	1	-	-	-	1	-	-
16	Crown	13	151	94	2	35	346	128	14	3	47	8	2
	Bowater	21	185	154	1	-	-	-	-	-	-	-	-
	Abitibi	4	4	4	-	-	-	-	-	-	-	-	-
17	Crown	32	295	237	2	15	141	52	5	2	17	3	1
	Bowater	5	64	52	1	22	262	97	10	8	92	15	4
	Abitibi	-	1	1	-	-	-	-	-	-	-	-	-
18	Crown	3	30	25	-	3	26	9	2	1	42	7	-
	Bowater	2	32	15	1	4	46	17	-	9	128	22	5
	Abitibi	1	9	9	-	-	-	-	-	-	-	-	-
	TNNP	10	100	65	7	30	297	107	13	-	-	-	-
	GMNP	32	340	340	-	10	101	36	5	26	263	37	11
TOTAL		1 974	20 395	14 129	634	1 908	19 816	5 847	729	811	8 479	1 100	221

Appendix IX. Area and volume of productive merchantable stands salvaged by 1982 by ownership and management unit where tree mortality caused by the spruce budworm was evident in Newfoundland.

Prov. manag. unit	Owner	Area and Volume Affected											
		A (dead)				B (moribund)				C (very severe)			
		Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)
5	Crown	4	32	27	2	4	32	12	3	1	13	2	1
6	Bowater	2	23	16	1	3	27	9	1	1	11	2	-
7	Crown	11	68	56	5	9	59	21	5	4	23	4	2
8	Crown	7	113	97	13	7	121	44	16	3	49	8	7
	Abitibi	2	16	11	1	2	19	7	1	1	8	1	-
9	Crown	11	98	84	11	14	124	45	17	5	45	8	6
	Bowater	21	192	164	22	29	265	95	36	15	132	24	22
	Abitibi	23	212	180	24	31	289	109	64	13	121	22	20
10	Abitibi	7	63	53	6	9	82	29	11	5	49	8	7
11	Abitibi	13	120	101	7	12	110	39	10	4	37	6	3
12	Abitibi	3	32	27	1	4	38	14	2	2	16	3	1
13	Abitibi	5	49	41	6	8	67	25	18	4	34	6	6
14	Crown	6	47	39	5	6	52	19	7	2	12	2	2
	Bowater	14	125	112	14	15	141	51	19	7	66	12	9
	Abitibi	3	26	23	1	3	31	11	1	1	13	2	-
15	Crown	1	13	8	1	1	11	4	1	-	4	1	-
	Bowater	31	290	244	32	34	316	114	43	13	123	22	17
16	Crown	-	2	1	-	-	2	1	-	-	1	-	-
17	Crown	4	23	16	3	4	20	7	3	2	8	1	1
18	Crown	3	29	24	2	3	26	9	2	1	42	7	3
TOTAL		171	1 573	1 324	157	198	1 832	665	260	84	807	141	107

Appendix X. Area and volume of productive merchantable stands burned by wildfire by 1982 by ownership and management unit where tree mortality caused by spruce budworm was evident in Newfoundland.

Prov. manag. unit	Owner	Area and Volume Affected								
		A (dead)				B (moribund)				
		Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	C (very severe)
2	Crown	-	-	-	-	2	19	6	1	
4	Abitibi	20	166	116	37	-	-	-	-	Nil
9	Bowater					37	369	114	33	
						1	8	3	-	
TOTAL		20	166	116	37	40	396	123	34	

Appendix XI. Areas and volumes of budworm damaged stands in Newfoundland classed as NSR (= Not Sufficiently Restocked) in 1982.

Prov. manag. unit	Owner	A (dead) Area(ha) (x 100)	A (dead) Total vol. m^3 (x 1000)	A (dead) Dead vol. m^3 (x 1000)	A (dead) Dying vol. m^3 (x 1000)	B (moribund)	C (very severe)
1	Crown	0	0	0	Nil	Nil	Nil
4	Abitibi	2	34	34			
5	Crown	1	7	7			
	Bowater	3	29	29			
	Abitibi	4	48	48			
6	Bowater	24	237	237			
	Abitibi	3	25	25			
7	Crown	33	334	334			
8	Crown	10	102	102			
	Bowater	2	16	16			
9	Crown	12	112	112			
	Bowater	8	77	77			
	Abitibi	5	57	57			
10	Crown	1	9	9			
	Abitibi	20	171	171			
11	Abitibi	9	90	90			
12	Crown	-	-	-			
	Abitibi	9	87	87			
13	Abitibi	3	38	38			
14	Crown	70	748	748			
	Bowater	22	250	250			
	Private	1	7	7			
15	Crown	42	424	424			
	Bowater	61	621	621			
16	Crown	4	41	41			
	Bowater	7	53	53			
	Abitibi	0	0	0			
17	Crown	3	31	31			
	Bowater	1	12	12			
	Abitibi	-	-	-			
18	Crown	-	-	-			
	Abitibi	0	0	0			
	GMNP	0	0	0			
TOTAL		360	3 660	3 660	0	0	0

Appendix XII. Areas and volumes of budworm damaged stands in Newfoundland that have blown down and were not salvable by 1982.

Prov. manag. unit	Owner	A (dead) Area(ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	B (moribund)	C (very severe)
1	Crown	3	20	20	Nil	Nil	Nil
4	Abitibi	3	50	50			
5	Crown	0	0	0			
	Bowater	3	29	29			
	Abitibi	12	146	146			
6	Bowater	1	10	10			
	Abitibi	0	0	0			
7	Crown	0	0	0			
8	Crown	0	0	0			
	Bowater	0	0	0			
9	Crown	13	122	122			
	Bowater	8	77	77			
	Abitibi	5	57	57			
10	Crown	3	26	26			
	Abitibi	17	145	145			
11	Abitibi	7	70	70			
12	Crown	-	-	-			
	Abitibi	11	107	107			
13	Abitibi	9	114	114			
14	Crown	18	192	192			
	Bowater	29	329	329			
	Private	0	0	0			
15	Crown	0	0	0			
	Bowater	8	81	81			
16	Crown	0	0	0			
	Bowater	7	53	53			
	Abitibi	4	4	4			
17	Crown	13	134	134			
	Bowater	0	0	0			
	Abitibi	-	-	-			
18	Crown	-	-	-			
	Abitibi	1	9	9			
	GMNP	32	340	340			
Total		207	2 115	2 115	0	0	0

Appendix XIII. Existing areas and volumes of productive merchantable stands by ownership and management unit where tree mortality caused by the spruce budworm was evident in Newfoundland in 1982.

Prov. manag. unit	Owner	Area and Volume Affected											
		A (dead)				B (moribund)				C (very severe)			
		Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)
1	Crown	3	15	6	3	16	92	21	5	4	21	1	1
	Private	-	-	-	-	1	6	1	-	-	5	-	-
2	Crown	-	-	-	-	103	794	168	45	29	242	13	4
4	Crown	-	-	-	-	-	1	-	-	-	-	-	-
	Bowater	-	2	1	-	-	-	-	-	-	-	-	-
	Abitibi	71	626	277	14	20	166	52	7	49	466	58	11
5	Crown	73	755	319	25	-	-	-	-	8	94	7	-
	Bowater	43	458	182	14	-	-	-	-	11	119	11	-
	Abitibi	14	144	66	4	-	-	-	-	2	23	2	-
6	Crown	1	10	6	1	-	2	1	-	-	-	-	-
	Bowater	91	1 141	664	64	213	2 538	879	71	-	-	-	-
	Abitibi	11	127	75	8	2	17	5	1	-	-	-	-
7	Crown	124	1 071	671	42	121	987	257	78	20	166	29	7
8	Crown	140	1 241	555	37	44	368	73	2	-	-	-	-
	Bowater	28	367	194	12	4	47	11	-	-	-	-	-
	Abitibi	2	24	8	-	1	8	1	-	-	-	-	-
	Private	-	-	-	-	-	-	-	-	-	-	-	-
9	Crown	67	784	504	46	55	544	131	29	87	690	11	-
	Bowater	45	586	350	30	184	2 071	537	159	63	416	12	-
	Abitibi	6	90	57	5	1	11	3	1	8	91	3	-
10	Crown	4	43	26	2	27	194	57	4	3	30	4	6
	Abitibi	61	637	381	26	166	1 731	525	41	50	525	65	99
11	Bowater	-	-	-	-	3	43	15	1	-	2	1	-
	Abitibi	36	369	225	11	54	543	181	17	71	725	240	67

(Cont'd.)

Appendix XIII. (Concl'd.)

Prov. manag. unit	Owner	Area and Volume Affected											
		A (dead)				B (moribund)				C (very severe)			
		Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)	Area (ha) (x 100)	Total vol. m^3 (x 1000)	Dead vol. m^3 (x 1000)	Dying vol. m^3 (x 1000)
12	Crown	-	-	-	-	21	226	61	13	-	-	-	-
	Abitibi	45	510	332	12	50	523	107	25	-	-	-	-
13	Abitibi	10	131	43	-	33	410	135	-	-	-	-	-
14	Crown	84	878	429	38	130	1 315	318	50	38	454	61	-
	Bowater	85	980	488	44	169	2 222	582	90	105	1 326	179	-
	Abitibi	23	295	145	13	35	486	130	19	62	869	117	-
	Private	11	98	48	4	23	204	51	7	2	30	4	-
15	Crown	21	204	117	25	18	176	67	5	10	116	8	-
	Bowater	72	788	452	134	62	695	269	17	58	720	53	-
	Private	3	32	18	6	-	1	-	-	-	1	-	-
16	Crown	9	109	52	1	35	345	127	14	3	47	8	2
	Bowater	7	80	48	1	-	-	-	-	-	-	-	-
17	Crown	12	107	56	2	11	121	45	5	1	9	2	-
	Bowater	4	51	40	1	22	262	97	10	8	91	15	4
18	Crown	-	-	-	-	-	-	-	-	-	-	-	-
	Bowater	2	32	16	-	3	38	14	2	9	128	22	5
	TNNP	10	100	65	7	30	297	107	13	-	-	-	-
	GMNP	-	-	-	-	10	101	36	5	26	263	37	10
TOTAL		1 218	12 884	6 916	632	1 667	17 585	5 064	736	727	7 669	963	216